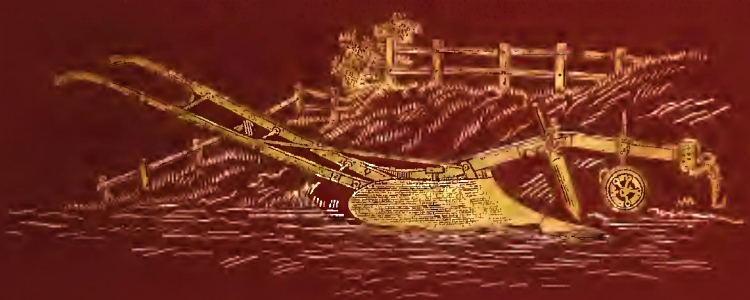

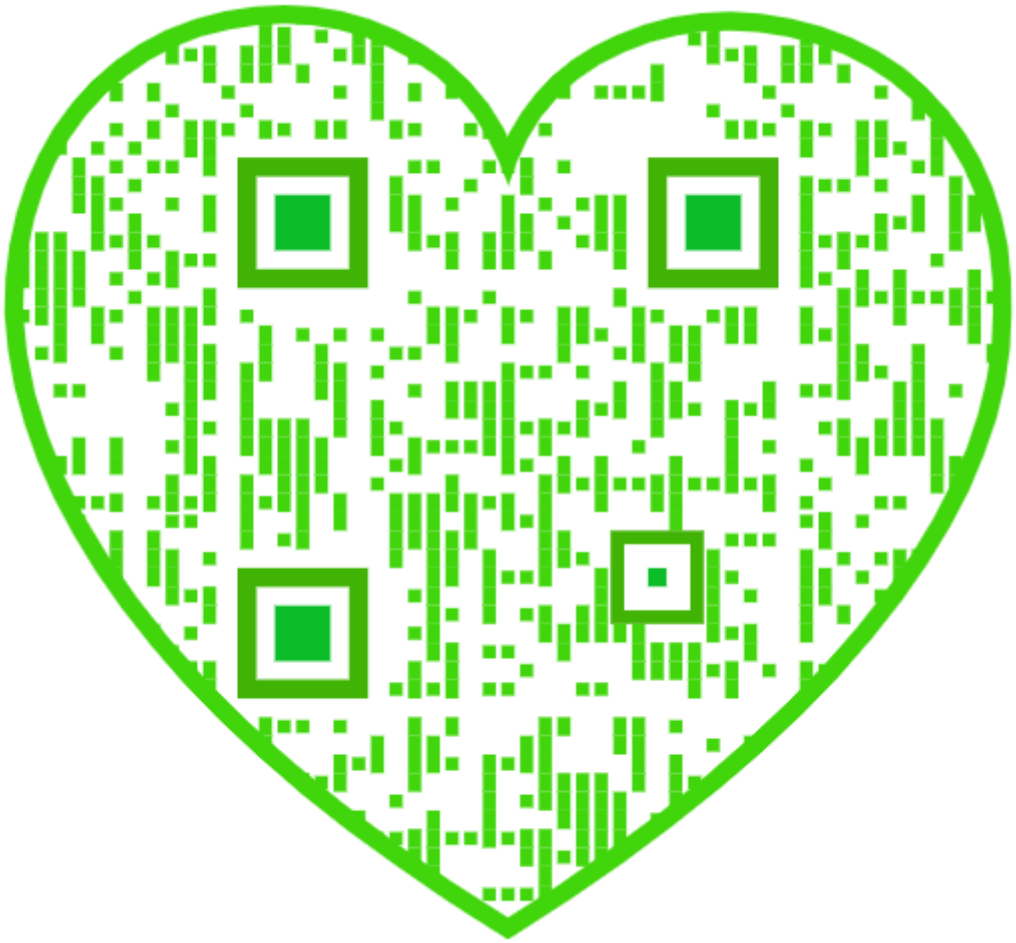

THE

BOOK OF THE FARM

Wherefore come on, O young husbandman!
Learn the culture proper to each kind.

VIRGIL.

THE

BOOK OF THE FARM

DETAILING THE LABOURS OF THE

FARMER, FARM-STEWARD, PLOUGHMAN, SHEPHERD, HEDGER, FARM-LABOURER, FIELD-WORKER, AND CATTLE-MAN

BY

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FOURTH EDITION

REVISED, AND IN GREAT PART REWRITTEN, BY

JAMES MACDONALD

OF THE 'FARMING WORLD';

AUTHOR OF 'FOOD FROM THE FAR WEST'; JOINT AUTHOR OF 'POLLED CATTLE,' 'HEREFORD CATTLE,' ETC., ETC.

IN THREE VOLUMES

VOLUME II.

WILLIAM BLACKWOOD AND SONS

EDINBURGH AND LONDON

MDCCCXCI

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PLATE V

John Sherrif A.R.S.A

Tho.s Landseer

DRAUGHT-STALLION.

(1840)

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Published by Wm Blackwood & Sons, Edinburgh & London.

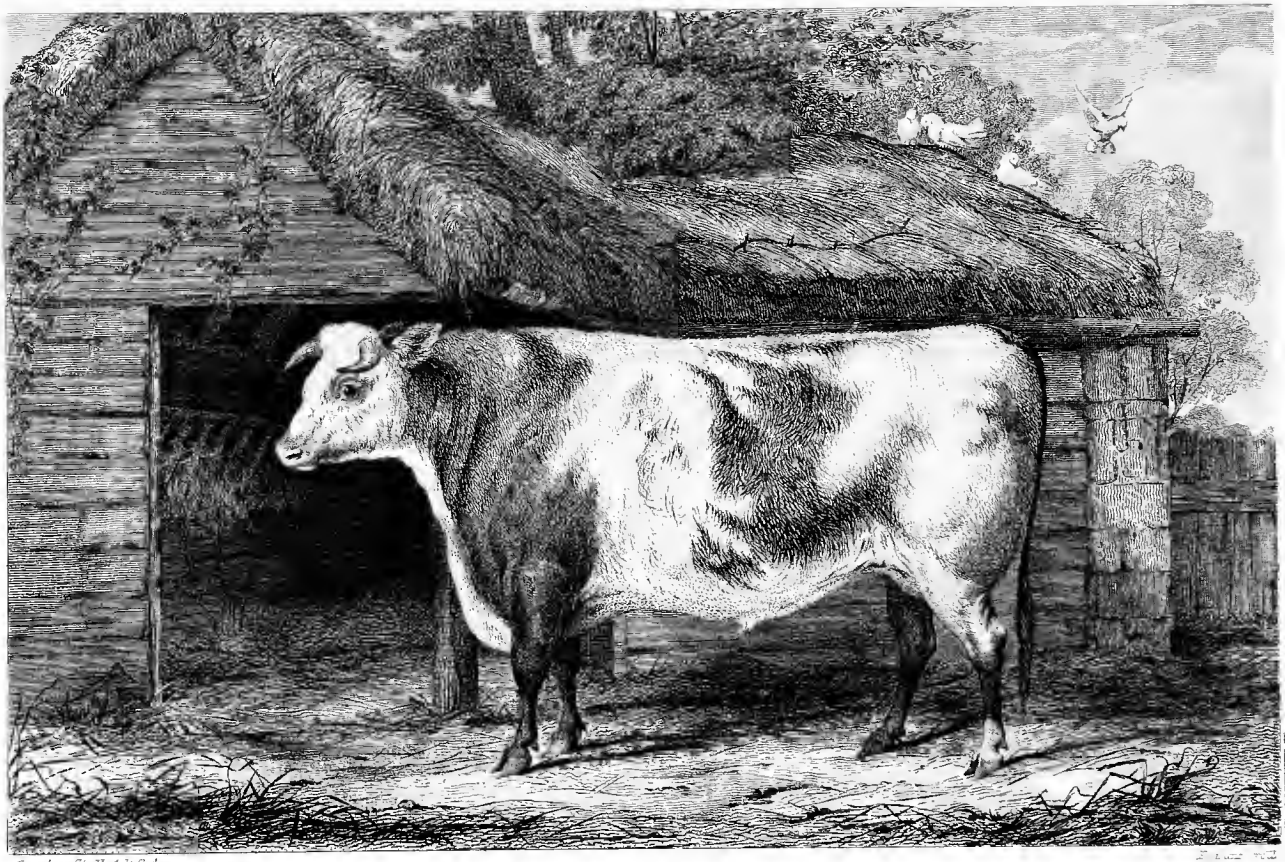

PLATE XI

Gourlay Steell, A.R.S.A

SHORT-HORN OX.

(1850)

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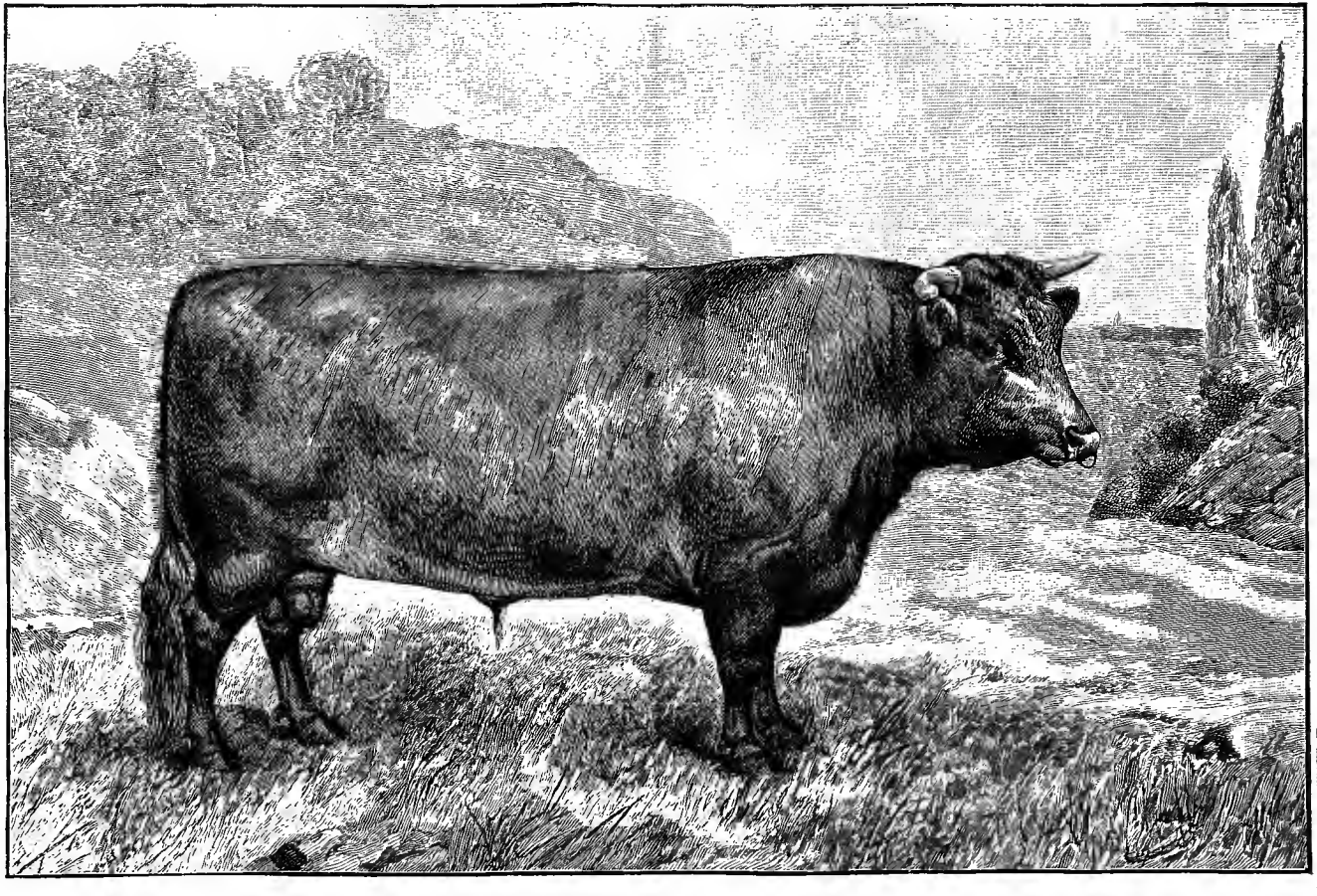

PLATE 14

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DEVON BULL, "LORD WOLSELEY."

THE PROPERTY OF THE VISCOUNT FALMOUTH, OF TREGOTHNAN, PROBUS, CORNWALL.

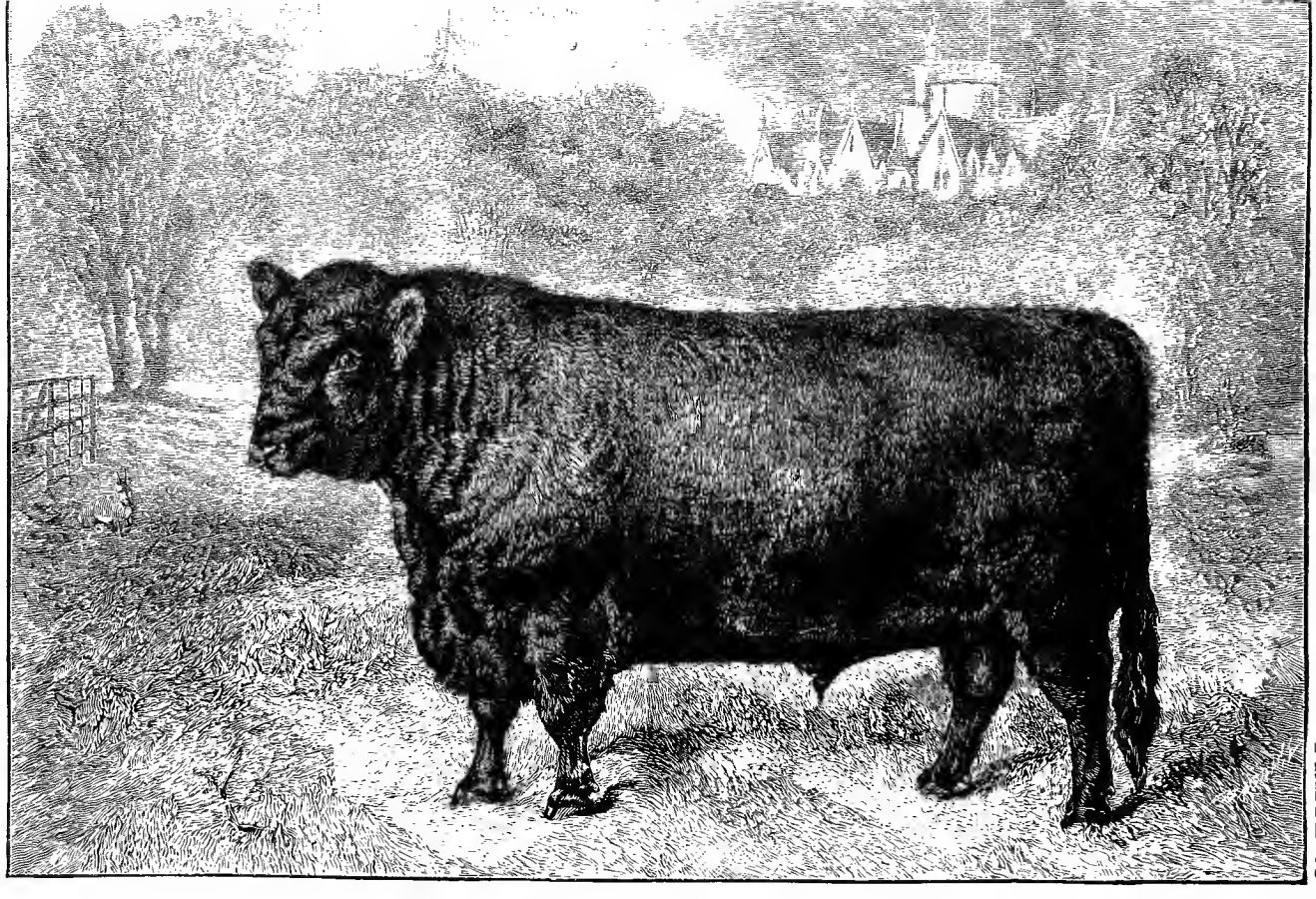

PLATE 13

GALLOWAY BULL, "MOSSTROOPER OF DRUMLANRIG," 1672.

THE PROPERTY OF SIR ROBERT JARDINE, BART., OF CASTLEMILK, M.P.

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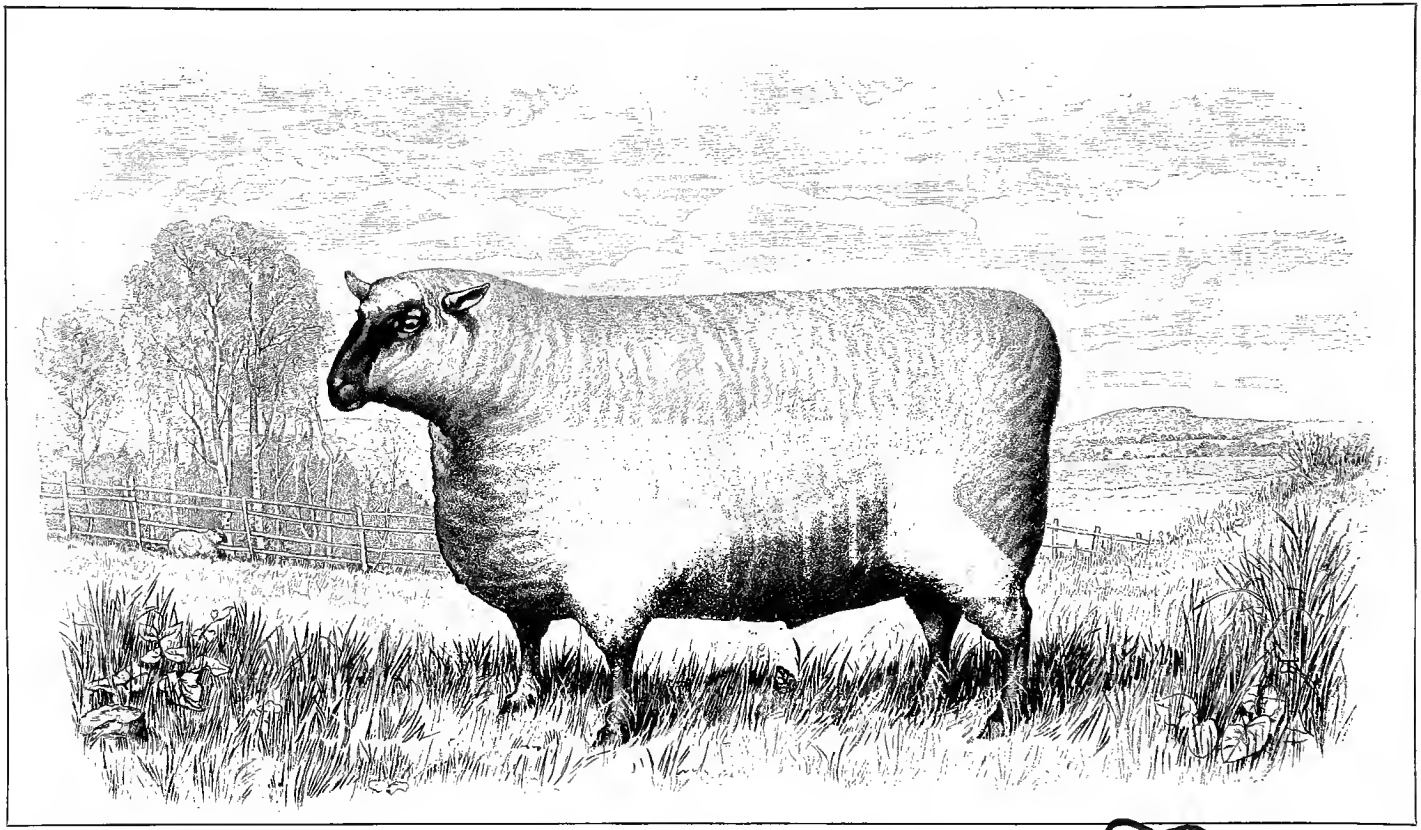

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PLATE 29

HAMPSHIRE DOWN WETHER.

THE PROPERTY OF HENRY LAMBERT, ESQ., BABRAHAM, CAMBRIDGE.

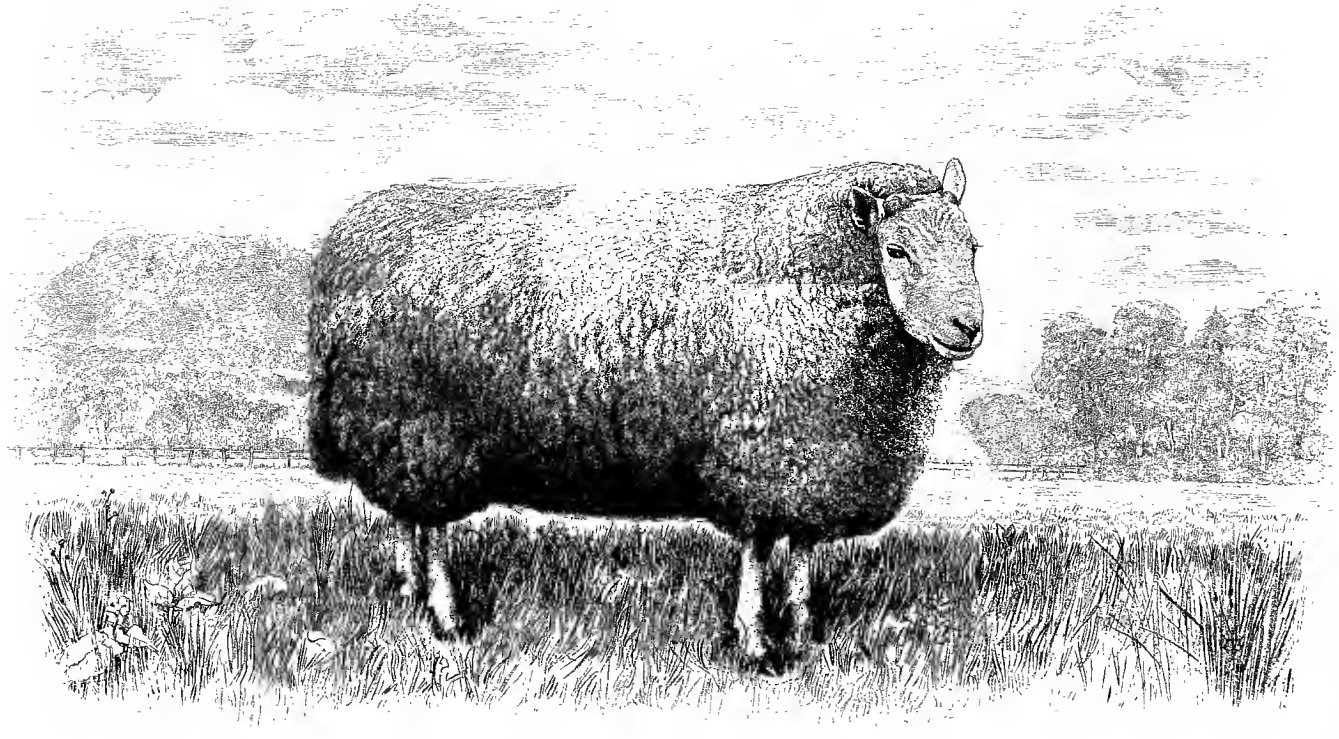

PLATE 35

CHEVIOT RAM.

THE PROPERTY OF JOHN ROBSON, ESQ, NEWTON, BELLINGHAM.

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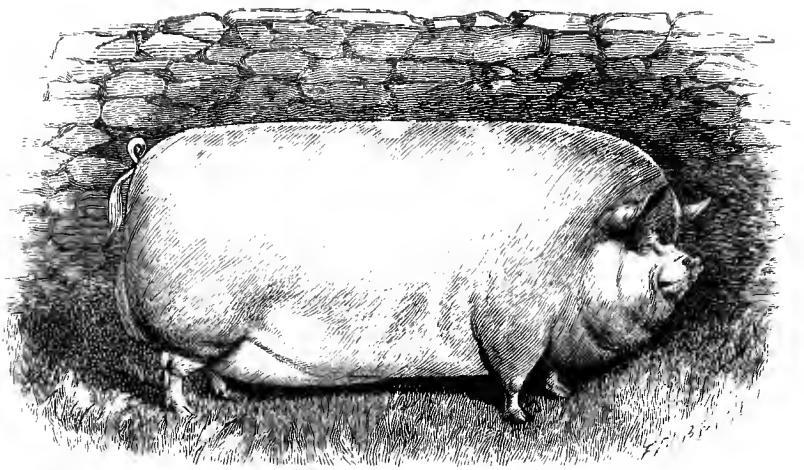
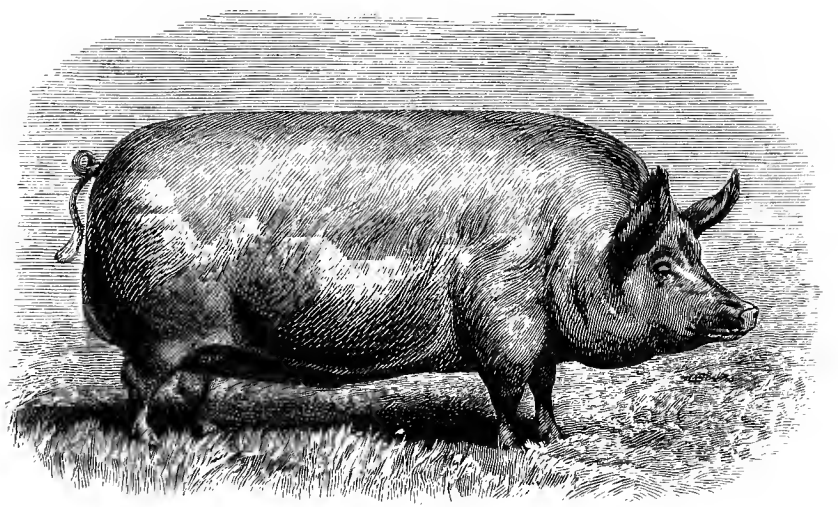
PLATE 37



MIDDLE-WHITE BOAR.

BRED BY SANDERS SPENCER, ESQ., OF HOLYWELL MANOR, ST IVES, HUNTS.



TAMWORTH BOAR.

THE PROPERTY OF THE AYLESBURY DAIRY COMPANY, HORSHAM, SUSSEX.

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THE

BOOK OF THE FARM.

SPRING.

FIELD OPERATIONS AND SPRING WEATHER.

In the vegetable world winter is the season of repose, of passive existence, of dormancy, though not of death. Spring, on the contrary, is the season of returning life, of passing into active exertion, of hope, and of joy; of hope, as the world of life springs into view immediately after the industrious hand has scattered the seed upon the ground—and of joy, in contemplating with confidence the reproductions of the herds and flocks. It would be vain to attempt to describe the emotions to which this delightful season gives birth. It is better that the pupil of agriculture should enjoy the pleasure for himself; for "the chosen draught, of which every lover of nature may drink, can be had, in its freshness and purity, only at the living fountain of nature; and if we attempt to fetch it away in the clay pitchers of human description, it loses all its spirit, becomes insipid, and acquires an earthy taste from the clay."

Early Rising and the Joys of Spring.—To enjoy the beauties of spring in perfection, "it is necessary to take advantage of the morning, when the beams of the newly risen sun are nearly level with the surface of the earth; and this is the time when the morning birds are in their finest song, when the earth and the air are in their greatest freshness, and when all nature mingles in one common morning hymn of gratitude. There is something peculiarly arousing and strengthening, both to the body and the mind, in the early time of the morning; and were we always wise enough to avail ourselves of it, it is almost incredible with what ease and pleasure the labours of the most diligent life might be performed. When we take the day by the beginning, we can regulate the length of it according to our necessities; and whatever may be our professional avocations, we have time to perform them, to cultivate our minds, and to worship our Maker, without the one duty interfering with the other."

The Morning of Life.—"The dayspring of the morning leads us, by an easy and very natural transition, to the dayspring of human life, the morning of our sojourn upon earth; and the parallels between the commencement of life itself, and of those successive days by which it is numbered, is a parallel the most striking. There is a freshness in young life

which no experience can acquire for us at any future time; and there is a newness in every object, which is not felt after years have passed over our heads. Our bodies are light, flexible, easily moved, and not liable to be injured. Our minds, too, never become wearied or listless; and although the occupation and the thought are necessarily different from those of persons of mature age, they are far more energetic, and what is learned or done takes a more permanent hold of the memory.

"There are many circumstances which render the morning of life of far more importance than the morning of an individual day. It is a morning to which no to-morrow morning can follow; and therefore, if it is neglected, all is inevitably and utterly lost. We cannot exactly make up the loss of even one morning, though we can repair it a little by our diligence in future mornings. We must bear in mind, however, that the means of doing this are a mercy to us, and not a privilege that we can command as our own. We never 'know what a day may bring forth;' and as there daily occur around us instances in which the young and the strong are at once levelled to the dust, we never can be certain that the demand shall not be made on ourselves—'this night is thy soul required of thee.' But if it is thus perilous to neglect one morning out of many, how much more perilous to neglect the one morning of a life—a life granted by a beneficent God, in a world full of the wonders of His power, capable of enjoyment, and deny Him service while it lasts, and in the fulness of time entering, through the atonement of the eternal Son, a life of bliss which shall have no end!"[1]

Cares of Stock-owners in Spring.—Spring is the busiest of all seasons on the farm. The cattle-man, besides continuing his attendance on the feeding cattle, has now the more delicate task of waiting on the cows at calving, and providing comfortable lairs for new-dropped calves. The dairymaid commences her labours, not in the peculiar avocations of the dairy, but in rearing calves—the support of a future herd. The farrows of pigs also claim a share of attention. The shepherd, too, has his painful watchings, day and night, on the lambing ewes; and his care of the tender lambs, until they are able to gambol upon the new grass, is a task of peculiar interest, and naturally leads to higher thoughts—"we cannot refrain from thinking of the unspeakable condescension and kindness of Him who 'feeds His flock like a shepherd, gathers the lambs into His arms, and carries them in His bosom, and gently leads those that are with young.'"

Field-work in Spring.—The condition of the fields demands attention as well as the reproduction of the stock. The day now affords as many hours for labour as are usually bestowed at any season in the field. The ploughmen, therefore, know no rest for at least ten hours every day, from the time the harrows are yoked for the spring wheat until the turnips are sown. The turnip land, bared as the turnips are consumed by sheep, or removed to the steading, is now ploughed and prepared for spring wheat, barley, or oats—that is, should the weather be mild and the soil dry enough. The first sowing is the spring wheat; then the beans, the oats, and the barley. The fields intended for the root crops then receive a cross-furrow, in the order of the fallow crops—the potatoes first, then turnips, and lastly the bare fallow, if there should be any, which is now very exceptional.

This is the course followed with the root-land in many cases, but where the stubbles are ploughed with a strong loose furrow in early winter, the soil is so pulverised by the influences of winter, that spring ploughing may be unnecessary, grubbing and harrowing being sufficient to bring it into the required condition. This will, of course, much depend upon the nature and condition of the land. Stiff, dirty land will most likely have to be cross-ploughed in spring, and grubbed once or even twice as well.

Grass seeds are then sown amongst the young autumnal wheat, as well as amongst the spring wheat and the barley or oats. The field-workers devote their busy hours to carrying seed to the sower, turning dunghills in preparation of the manure for the potato and turnip crops, continuing the barn-work to supply litter for the

[1] Mudie's *Spring*, 12-15.

stock yet confined in the steading, and to prepare the seed-corn for the fields. The hedger resumes his work of water-tabling and scouring ditches, cutting down and breasting old hedges, and taking care to fence with paling the young quicks upon the hedge-bank, which he may have planted at the commencement and during fresh weather in winter, as also to make gaw-cuts in the sowed fields.

The steward is now on the alert, urges the progress of every operation, and intrusts the sowing of the crops to none but himself, or a tried hand, as the skilful hedger, or ploughman experienced in the management of an approved corn-sowing machine. Thus every class of labourers have their work appropriated for them at this busy season; and as the work of every one is individually defined, it is scarcely possible for so great a mistake to be committed as that any piece of work should be neglected by all.

The Farmer's Duties in Spring.—The farmer himself now feels that he must be "up and doing." His mind becomes stored with plans for future execution; and in order to see them executed at the proper time and in the best manner, he must now forego all visits, and remain at home for the season; or at most undertake an occasional and hasty journey to the market town to dispose of surplus corn and transact other pressing business. The work of the fields now requiring constant attendance, his mind as well as body becomes fatigued, and, on taking the fireside after the labours of the day are over, the farmer seeks for rest and relaxation rather than mental toil. He should at this season pay particular attention to the state of the weather, by observing the barometric and thermometric changes, and make it a point to observe every external phenomenon that has a bearing upon the changes of the atmosphere, and be guided accordingly in giving his instructions to his people.

Weather in Spring.—The weather in spring, in the zone we inhabit, is exceedingly variable, alternating, at short intervals, from frost to thaw, from rain to snow, from sunshine to cloud—very different from the steady character of the arctic spring, in which the snow melts without rain, and the meads are covered with vernal flowers ere the last traces of winter have disappeared. Possessing this variability in its atmospherical phenomena, spring presents few having peculiarities of their own, unless we except the cold unwholesome east wind which prevails from March to May, and the very heavy falls of snow which occasionally occur in February.

East Wind.—So invariable is the phenomenon of the *east wind* in spring, that every person who dwells on the east coast of Great Britain is quite familiar with it, having felt its keenness and known its aptitude to produce catarrhal, pulmonary, and rheumatic affections. In its dread, many migrate to a milder climate until summer shall have set in. An explanation of this remarkable phenomenon has been given by Mr Samuel Marshall. "In Sweden and Norway," he observes, "the face of the country is covered with snow to the middle of May or longer. This frozen covering, which has been formed during winter, grows gradually shallower to the 15th or 16th of May, or until the sun has acquired 17° or 18° N. declination; while, on the other hand, the valleys and mountains of England have received an accession of 24° or 25°. On this account, when the temperature of Sweden and Narway is cooled down by snow to 32°, that of Britain is 24° or 25° higher than that of the preceding countries. Because, while the ground is covered with snow, the rays of the sun are incapable of heating the air above 32°, the freezing-point. For this reason the air of England is 24° or 25° more heated than that of the before-mentioned countries. The air of Sweden and Norway will then, of course, by the law of comparative specific gravity, displace that of England, and, from the relative situation of those countries with this country, will produce a N.E. wind. The current is in common stronger by day than by night, because the variation of temperature is at that time the greatest, being frequently from 50° to 60° about noon, and sinking to 32° in the night."[1]

Spring Winds.—All the seasons have their peculiar influence on the winds.

[1] Brewster's *Jour. Sci.*, viii. 39.

"In *spring*," says Schouw, "E. winds are common; at certain places in March, at others in April. They diminish the force of the W. current, which in many countries is at that time weaker than during the rest of the year. The relation of N. to S. winds is not constant, and varies according to the localities. In some the direction is more N., in others more S., than the mean direction of the year." "When winds come from distant countries, they possess a part of the properties by which those countries are characterised," is an observation of Kaemtz. "Thus the W. winds, that blow from the sea, are much more moist than the E., which traverse continents. The latter, particularly when they are N.E., are very cold, especially in spring; and they give rise to a great number of rheumatic affections. The very opposite sensations, produced by violent S. or N. winds, are much more marked in countries whose inhabitants live in the open air."

Kaemtz further explains the cause of the very variable nature of the wind in our countries. After having mentioned that the two great leading currents of wind on the globe are the N.E. and S.W., he observes that "meteorological registers present to us the indication of a great number of winds which blow from all parts of the horizon. When we compare corresponding observations made in many localities in Europe, we are not slow in recognising that those winds involve no other causes than difference of temperature. Suppose, for instance, that a general S.W. wind occupies the upper regions, but that the W. part of Europe is very hot, whilst the E. regions remain very cold, with a clouded sky, the difference of temperature will immediately give rise to an E. wind; and when this wind meets that from the S.W. there will be a S.E. wind, which may be transformed into a true S. wind.

"These differences of temperature explain the existence of almost all winds. Now, suppose that a region is unusually heated, and that there is no prevailing wind, then the cold air will flow in on all sides; and according as the observer is in the N., the E., the S., or the W., he will feel a different wind blowing from the corresponding points of the horizon. However, to put the fact beyond doubt, we need corresponding observations, embracing a great number of localities,"[1] an advantage now very efficiently provided by the Royal Meteorological Society and the Scottish Meteorological Society.

The character of the winds in spring is, that they are very sharp when coming from the N. or N.E. direction; and they are also frequent, blowing strongly sometimes from the E. and sometimes from the W. In the E. they are piercing, even though not inclining to frost; in the W. they are strong, boisterous, squally, and rising at times into tremendous hurricanes, in which trees escape being uprooted only in consequence of their leafless state, but by which many a hapless mariner is overtaken and consigned to a watery grave, or dashed without mercy on a rocky shore.

Snow in Spring.—Very frequently snow covers the ground for a time in spring. The severest snow storms and falls usually occur in February. Truly awful is a storm of snow in spring amongst the hills.

It is a serious affliction to the sheep-farmer when a severe and protracted snowstorm occurs in spring. The losses caused by the storm are often very great, especially in breeding flocks, where lambs are sometimes lost in hundreds daily. Then by providing extra food for sheep in spring storms, the sheep-farmer's outlays are frequently increased to a serious extent.

Clouds in Spring.—The prevailing *clouds* in spring are the same as in winter—namely, the *cirro-stratus*, which more frequently gathers itself into the *cumulo-stratus*, and hovers about the horizon, and either subsides entirely below it on the approach of frost at night, or veils the zenith in the daytime in the form of *cirro-stratus;* but the *cumulo-stratus* of spring presents a very different aspect to what it does in summer, having generally a well-defined though ragged margin, and a peculiar look of transparency or clearness, which is preserved even when the clouds become purple or nearly black.

Rain in Spring.—The character of rain in spring is sudden, violent, and

[1] Kaemtz's *Cour. Meteoro.*, 50-54.

cold, not unfrequently attended with hail.

Evaporation in Spring.—Evaporation is quick in spring, especially with an E. wind, the surface of the ground being as easily dried as wetted. Thus two or three days of drought will raise the dust in March, and hence the cold felt on such occasions.

Prognostics of Spring.—The weather in spring may be regarded as the keystone to that of the ensuing seasons. Its indications are analogous to those of *cirri*, which make the first movement in the upper regions of the sky when a change is about to take place in the state of the atmosphere. The *prognostics* of spring are therefore worthy of attention, and the enumeration of a few of them may point to that class of phenomena which deserves the greatest attention at this season.

Dalton says that the *barometer* is at the lowest of all during a thaw following a long frost, and is often brought down by a S.W. wind. When the barometer is near the high extreme for the season of the year, there is very little probability of immediate rain; when the barometer is low for the season, there is seldom a great weight of rain, though a fair day in such a case is rare; the general tenor of the weather at such times is short, heavy, and sudden showers, with squalls of wind from the S.W., W., or N.W. When the appearance of the sky is very promising for fair weather, and the barometer at the same time low, it may be depended upon that the appearances will not long continue so; the face of the sky changes very suddenly on such occasions. Very dark and dense clouds pass over without rain when the barometer is high; whereas, when the barometer is low, it sometimes rains almost without any appearance of clouds. A sudden and extreme change in *temperature*, either from heat to cold, or from cold to heat, is generally followed by rain within 24 hours.

Weather Proverbs.—Many prognostics of the weather have been received as proverbs by the country people; and as these have become current only after mature experience, we may rely on their accuracy. These are a few relating to spring:—

February.

February fill dyke, be it black or be it white:
But if it be white, it's the better to like.

The hind has as leif see his wife on the bier,
As that Candlemas day should be pleasant and clear.

If Candlemas day be fair and clear,
The half o' winter is to gang and mair;
But if Candlemas day be foul,
The half o' winter is gane at Yule.

March.

March hack ham, comes in like a lion, goes out like a lamb.

A bushel of March dust is worth a king's ransom.

March grass never did good.

A windy March, and a showery April, make a beautiful May.

March wind and May sun
Make clothes white and maids dun.

So many frosts in March, so many in May.

March many weathers.

March birds are best.

April.

April showers bring forth May flowers.

When that Aprili's with her showery soote
The droughte of March had pierced to the roote.

When April blows his horn,
It's good both for hay and corn.

A cold April the barn will fill.

The *borrowing days*—the last days of March and the first days of April—are proverbially stormy. This well-known rhyme is regarding them:—

March said to Averil,
Do you see thae hoggs on yonder hill?
If ye lend me days three,
I'll do my best to gaur them dee.
The first day was wind and weet,
The second day was snaw and sleet,
The third day was sic a freeze
As festen'd the birdies to the trees;
But when the three days war come and gane,
A' the wee hoggies gaed hirplin' hame.

Birds in Spring Storms.—During a snowstorm in spring, wild birds, becoming almost famished, resort to the haunts of man. The robin is a constant visitor, and helps himself with confidence to the crumbs placed for his use. The male partridge calls in the evening within sight of the house, in hopes of obtaining

some support before collecting his covey together for the night to rest upon the snow.

Hares have been known to come to the door in the evening, and through the night in the moonlight, to receive the food set down for them. Rooks now make desperate attacks upon the stacks, and will soon make their way through the thatch. Beginning their attacks at the top, they seem to be aware of the exact place where the corn can be most easily reached. Sparrows burrow in the thatch; and even the diminutive tomtit, with a strength and perseverance one should suppose beyond its ability, pulls out whole straws from the side of the stacks, to procure the grain in the ear.

Further on in spring, the insect world come into active life in myriads, to serve as food for the feathered tribes. Rooks, with sturdy walk and independent gait, diligently search the ground for them, in the wake of the plough, and feed their young therewith. Tomtits clamber round every branch of trees which indicate an opening of their floret buds. A stream of migration to the north, of wild geese and other water-fowl, betokens the approach of genial weather.

Cottage Gardening.—"By the time the season is fairly confirmed, the leisure hours of the cottagers," and of the ploughmen, who are cottagers of the best description, are spent, in the evening, "in the pleasing labour, not unaccompanied with amusement, of trimming their little gardens, and getting in their early crops. There is no sort of village occupation which men, women, and children set about with greater glee and animation than this; for, independently of the hope of the produce, there is a pleasure to the simple and unsophisticated heart in 'seeing things grow,' which, perhaps, they who feel the most are least able to explain.

"Certain it is, however, that it would be highly desirable that not only every country labourer, but every artisan in towns, where these are not so large as to prevent the possibility of it, should have a little bit of garden, and should fulfil the duty which devolved on man in a state of innocence, 'to keep it and to dress it.' It is impossible for any one who has not carefully attended to the subject, to be at all aware how strong the tie is which binds man even to a little spot of his native earth, if so be that he can consider it as his own, and that he himself, and those on whom he loves to bestow it, are to enjoy the fruit.

"This is the very strongest natural hold which binds a poor man to his country, and to all those institutions established for the wellbeing of society. Show me the cottage, the roses and the honeysuckles on which are neatly trimmed and trained, and the garden behind is well stocked with culinary herbs and a few choice flowers, and I will speedily find you a cottager who never wastes his time or money, or debases his mind, and learns 'the broad road which leadeth to destruction,' in the contamination of an alehouse. If the garden is neat, one may rest assured that the cottage, however humble it is, is the abode of contentment and happiness; and that, however simple the fare may be, it is wealth and luxury in full store to the inmates, because they are satisfied with it, and grateful for the possession of it."[1] The contentment of the married ploughmen—in districts where comfortable cottages and little garden-plots are provided—and the attachment to the farm upon which they serve, may be traced to the feelings expressed in these remarks.

The Farmer's Garden.—Farmers, as a rule, are bad gardeners. Not unfrequently the garden, or where the garden should be, is one of the most thoroughly neglected spots on the farm. This is much to be regretted, for the value of a good, well-stocked kitchen-garden to a household is very great. There should be a garden on every farm, and it may be kept in good order at trifling expense. The hedger, stableman, or some other of the farm-servants, should know as much of the art of gardening as to be able to keep the farmer's garden in decent order in the absence of a gardener, whose assistance may with advantage be called in to crop the ground in the respective seasons. A field-worker now and then could keep the weeds in subjection, and allow both sun and air free access to the growing plants. Besides carelessness about the garden, the

[1] Mudie's *Spring*, 274-275.

same feeling is evinced by too many farmers in the slovenly state in which the shrubbery and little avenue attached to their dwelling are kept.

Fat Cattle. — In spring the farmer thinks of disposing of the remainder of his fat cattle. Should he not be offered the price he considers them worth, he may keep them on for a time—a few of them perhaps for a month or two on grass—for beef is usually plentiful and cheap in spring, and scarce and dear early in summer.

Grass Parks.—Spring is the season for letting grass parks. In the majority of cases the parks are held by landed proprietors. The ready demand for old grass induces the retention of pleasure-grounds in permanent pasture, and removes temptation from a landlord to speculate in cattle. It is not customary for farmers to let grass parks, except in the neighbourhood of large towns, where cowfeeders and butchers find them so convenient as to induce them to tempt farmers with high prices. Facility of obtaining grass parks in the country is useful to the farmer who raises grazing stock, when he can give them a better bite or warmer shelter than he can offer them himself, on the division of the farm which happens to be in grass at the time.

Selling Wood.—The landed proprietor has also to seek a market in spring for his *timber*, which he annually fells in thinning his plantations. Such sales afford convenient supplies to farmers in want of paling for fencing new hedges, wood for sheep-flakes or stobs, or timber for the erection of shedding for animals, or for implements. They are also serviceable to country joiners and implement-makers, in affording them necessary materials nigh at hand. The timber is felled by the owner, and assorted into lots of sizes and kinds best suited to the local demand. Prunings and thinnings are sold as firewood.

ADVANTAGES OF HAVING FIELD-WORK WELL ADVANCED.

The season — *early spring* — having arrived when the labouring and sowing of the land for the various crops cultivated on a farm of mixed husbandry are about to occupy all hands for several months to come, the injunction of old Tusser to undertake them in time, so that each may be finished in its proper season, should be regarded as sound advice. When field-labour is advanced ever so little at every opportunity of weather and leisure, no premature approach of the ensuing season can come unawares; and no delay beyond the usual period will find the farmer unprepared to proceed with the work. When work proceeds by degrees, there is time to do it effectually. If it is not so done, the farmer has himself to blame for not looking after it. When work is advancing by degrees, it should not be allowed to be done in a careless manner, but with due care and method, so as to impress the work-people with the importance of what they are doing. The advantage of doing even a little effectually is not to have it to do over again afterwards; and a small piece of work may be done as *well*, and in as short a time, in proportion, as a greater operation.

Keep the Plough going.—Even if only one man is kept constantly at the plough, he would turn over, in the course of a time considered short when looked back upon, an extent of ground almost incredible. He will turn over an imperial acre a-day—that is, 6 acres a-week, 24 acres in a month, and 72 acres in the course of the dark and short days of the winter quarter. All this he will accomplish on the supposition that he has been enabled to go at the plough every working day; but as that cannot probably happen in the winter quarter, suppose he turns over 50 acres in that time, these will still comprehend the whole extent of ground allotted to be worked by every pair of horses in the year. Thus a large proportion of a whole year's work is done in a single, and that the shortest, quarter of the year. Now, a week or two may quickly pass, in winter, in doing things which, in fact, amount to time being thrown away.

Instances of misdirected labour are too apt to be regarded as trifles *in winter;* but they occupy as much time as the most important work—and at a season, too, when every operation of the field is directly preparatory to others to be executed in a more busy season.

Neglected Work inefficiently done.—The state of the work should be a subject for the farmer's frequent consideration, whether or not it is as far advanced as it should be; and should he find the work to be backward, he consoles his unsatisfied mind that when the season for active work really arrives, the people will make up for the lost time. Mere delusion—for if work can be made up, so can *time*, the two being inseparable; and yet, how can lost time be made up, when it requires every moment of the year to fulfil its duties, and which is usually found too short in which to do everything as it *ought to be done?* The result will always be that the neglected work is done in an inefficient manner.

Subdivision of Farm-work.—*Field*-labour should be perseveringly advanced in winter, whenever practicable; and some consider it a good plan, for this purpose, to apportion certain ploughmen to different departments of labour—some to work constantly on the farm, some constantly at the plough, others frequently at the cart. When the elder men and old horses, or mares in foal, are appointed especially to plough, that most important of all operations will be well and perseveringly executed, while the young men and horses are best suited for carting when not at the plough. Thus the benefits of the subdivision of labour may be extended to farm operations.

Advancing Field-work.—It is right to give familiar examples of what is meant by the advantage of having field-labour advanced whenever practicable. The chief work in spring is to sow the ensuing crops. It should therefore be the study of the farmer in winter to advance the work for spring sowing. When the weather is favourable for sowing spring wheat, a portion of the land, cleared of turnips by the sheep, may perhaps be ploughed for wheat instead of barley. If beans are cultivated, let the ploughing suited to their growth be executed; and in whatever mode beans are cultivated, care should be taken in winter to have the land particularly dry, by a few additional gaw-cuts where necessary, or clearing out those already existing. Where common oats are to be sown, they being sown earlier than the other sorts, the lea intended for them should be ploughed first, and the land kept dry; so that the worst weather in spring may not find the land in an unprepared state. The land intended for potatoes, for turnips, or tares, or bare fallow, should be prepared in their respective order; and when every one of all these objects has been prepared for, and little to do till the burst of spring work arrives, both horses and men may enjoy a day's rest now and then, without any risk of throwing work back.

Spring Preliminaries.—But besides field operations, other matters require attention ere spring work come. The implements required for spring work, great and small, have to be repaired—the plough-irons new laid; the harrow-tines new laid, sharpened, and firmly fastened; the harness tight and strong; the sacks patched and darned, that no seed-corn be spilt upon the road; the seed-corn threshed, measured up, and sacked, and what may be last wanted put into the granary; the horses new shod, that no casting or breaking of a single shoe may throw a pair of horses out of work for even a single hour;—in short, to have everything ready to start for the work whenever the first notice of spring shall be heralded in the sky.

Evils of Procrastination.—But suppose all these things have been neglected until they are wanted—that the plough-irons and harrow-tines have to be laid and sharpened, when perhaps to-morrow they may be wanted in the field—a stack to be threshed for seed-corn or for horse's corn when the sowing of a field should be proceeded with; suppose that only a week's work has been lost, in winter, of a single pair of horses, 6 acres of land will have to be ploughed when they should have been sown,—that instead of having turnips in store for the cattle when the oat-seed is begun, the farmer is obliged to send part of the draughts to fetch turnips—which cannot then be stored—and the cattle will have to be supplied with them from the field during all the busy season.

In short, suppose that the season of incessant labour arrives and finds every one unprepared to go along with it, what must be the consequences? Every creature, man, woman, and beast, will then be toiled beyond endurance every day,

not to *keep up* work, which is a lightsome task, but to *make up* work, which is a toilsome burden. Time was lost and idled away at a season considered of little value; thus exemplifying the maxim, that "procrastination is the thief of time"—and after all, the toil will be bestowed in vain, as it will be impossible to sow the crop *in due season*. Those implicated in procrastination may fancy this to be a highly coloured picture; but it is drawn from life.

CATTLE IN SPRING.

To the stock-owner the spring months are full of hopes and anxieties. At the opening of the season calving will most probably be in full swing; and in breeding stocks this is the most critical period in the whole year. Naturally, therefore, the treatment of cows and their young produce demands our first consideration at this time.

THE CALVING SEASON.

The calving of cows is one of the chief events of the spring upon stock farms. Not that calving does not occur until spring—for most breeders of farm-stock are anxious to have calves early, particularly bull-calves, and for that purpose calves are born as early as the month of December. Besides, those in the new-milk trade require to have the animals dropping their young at intervals during the whole year. Still by far the largest proportion of cows do not calve until January, February, and March, and the season of calving continues good till the middle of April. After that date the calves are accounted late.

An early calf possesses the advantage of having passed through its period of milk-drinking in time to be supported upon grass, as soon as it affords sufficiency of food. *A late calf* somehow seems never to fully regain the lost time.

Risks of the Calving Season.—From eight to ten weeks at this season is a period of great anxiety for the state of the cows. Every care, therefore, that can conduce to her passing in safety over this critical period ought to be cheerfully bestowed. When the cow first shows heavy in calf, which is after the sixth month, the litter in the court should not be too deep, as over-exertion in wading through soft litter may cause such an excited action of the cow's system as to make her slip calf. The litter in a court constantly trampled by cattle at freedom becomes firm, and affords a good footing, and the cattleman should spread every barrowful thinly.

Cows, as they calve, and after it is safe for them to go into the air, should not go into the court at the same time with those yet to calve; as calved cows soon *come into season*—that is, desire the bull—and when in this state, the other cows ride upon them, and this propensity is strongest in those cows yet uncalved. Such violent action, upon soft litter, is likely to prove injurious to uncalved cows. The time of day in which cows in different states may go out, should be left to the discretion of the cattle-man, who knows that cows, after calving, become more tender in their habit than before, and should have the best part of the day—from 12 to 2 o'clock.

Symptoms of Pregnancy.—Cows may be ascertained to be in calf between the fifth and sixth months of their gestation. The calf quickens at between four and five months. The calf may be felt by thrusting the points of the fingers against the right flank of the cow, when a hard lump will bound against the abdomen, and be felt by the fingers. Or when a pailful of *cold* water is drunk by the cow, the calf kicks, when a convulsive sort of motion may be observed in the flank, by looking at it from behind, and if the open hand is then laid upon the space between the flank and udder, this motion may be most distinctly felt. It is not in every case that the calf can be felt at so early a period of

its existence; for lying then in its natural position in the interior of the womb, it cannot be felt at all; and when it lies near the left side of the cow, it is not so easily felt as on the opposite one. So that, although the calf cannot be *felt* at that early stage, it is no proof that the cow is not in calf.

When a resinous-looking substance can be drawn from the teats by stripping them firmly, the cow is sure to be pregnant. After five or six months, the flank in the right side fills up, and the general enlargement of the under part of the abdomen affords an unequivocal symptom of pregnancy.

But there is seldom any necessity for thus trying whether a cow is in calf, for if she has not sought the bull for some months, it is almost certain to be because she is pregnant.

Youatt's Method of Testing Pregnancy.—These are the common modes of ascertaining the pregnant state of the cow; but Youatt has afforded us more scientific means of ascertaining the fact. He says he would not give, nor suffer any one else to give, those terrible punches on the right flank, which he had no doubt were the cause of much unsuspected injury, and occasionally, at least, were connected with, or were the origin of, difficult or fatal parturition. At a very early stage of the gestation, he says, by introducing the hand gently and cautiously into the vagina, the state of the womb may be ascertained. If it is in its natural state, the mouth of the womb or *os uteri* will be closed, though not tightly so; but if it is impregnated, the entrance of the uterus will be more firmly closed, and the protrusion will be towards the vagina. He adds a caution, however, in using this mode of exploration: "When half, or more than half, of the period of pregnancy is passed, it is not at all unlikely that so much irritation of the parts will ensue as to cause the expulsion of the fœtus." He would rather introduce his hand into the rectum, and as the fœtus of two months is still in the pelvic cavity, he would feel the little substance under his hand. He adds: "I am certain that I am pressing upon the uterus and its contents. I cannot, perhaps, detect the pulsation of the embryo; but if I had delayed my examination until the fœtus was three months old, I should have assurance that it was there by its now increased bulk, while the pulsation of its heart would tell me that it was living."

When still older, the pulsation of the heart may be distinctly heard on applying the ear closely to the flank here and there, and upwards and downwards, while the cow is held quietly and steadily.

Cow's Womb.—The womb of the cow is a bag of irregular form, having a chamber or division attached to each side, called the horns of the womb; and so called, perhaps, because of the horn-like form they present in an unimpregnated state. The womb consists almost entirely of muscular fibres, with a large proportion of blood-vessels and of vascular matter, which admits of contraction and extension. Its ordinary size in a large cow is about 2½ feet in length, but, when containing a full-grown fœtus, it is 7 feet in length. This is an extraordinary adaptation to circumstances which the womb possesses, to bear an expansion of 7 feet, from about a third of that length, and yet be capable of performing all its functions.

The Fœtus.—"The fœtus of the cow is huddled up in the right side of the belly," says Youatt. "There its motions are best seen, and the beatings of its heart best heard. The enormous paunch, lying principally in the left side, presses every other viscus, and the uterus among the rest, into the right flank.

Indication of Twins.—"This also explains a circumstance familiar to every breeder. If the cow should happen to carry twins they are crowded together in the right flank, and one seems absolutely to lie upon the other. Whenever the farmer notices the kicking of the fœtus high up in the flank, he at once calculates on twins."[1]

Reckoning Time of Calving.—The exact time of a cow's calving should be known by the cattle-man as well as by the farmer himself, for the time when she was served by the bull should be registered. Although this last circum-

[1] *Jour. Agric. Soc. Eng.*, i. 172.

stance is not a certain proof that the cow is in calf, yet if she has passed the period when she should have taken the bull again without showing symptoms of season, it may safely be inferred that she became in calf at the last serving, from which date should be calculated the period of gestation, or of *reckoning*, as it is called.

A cow is reckoned to go just over 9 months with calf, although the calving is not certain to a day. The experiments of the late Earl Spencer afford useful information on this point. After keeping the record of the calving of 764 cows, he came to this conclusion: "It will be seen that the shortest period of gestation, when a live calf was produced, was 220 days, and the longest 313 days; but I have not been able to rear any calf at an earlier period than 242 days. Any calf produced at an earlier period than 260 days must be considered decidedly premature; and any period of gestation exceeding 300 days must also be considered irregular: but in this latter case the health of the produce is not affected. It will also be seen that 314 cows calved before the 284th day, and 310 calved after the 285th; so that the probable period of gestation ought to be considered 284 or 285 days, and not 270, as generally believed."

Indication of Bull-calves.—It is also a popular belief that when a cow exceeds the calculated period of gestation, she will give birth to a bull-calf. The belief accords so far with experience. Lord Spencer observes, "In order fairly to try this, the cows that calved before the 260th day, and those that calved after the 300th, ought to be omitted as being anomalous cases, as well as the cases in which twins are produced; and it will then appear that from the cows whose period of gestation did not exceed 286 days, the number of cow-calves produced was 233, and the number of bull-calves 234; while of those whose period exceeded 286 days, the number of cow-calves was only 90, while the number of bull-calves was 152."[1]

Calf-bed coming Down.—Cows are most liable to the complaint of the coming down of the calf-bed, when near the period of calving, between the eighth and ninth months, and, from whatever cause it may originate, the position of the cow, as she lies in her stall, should be amended by raising her hind quarters as high as the fore by means of the litter. The immediate cause of the protrusion of a part of the womb is, the pressure of the calf's fore feet and head against that part of it which is opposite to the vaginal passage, and the protrusion mostly occurs when the calf is in its natural position; so that, although no great danger need be apprehended from the protrusion, it is better to use means to prevent its recurrence than to incur bad consequences by indifference or neglect.

Feeding In-calf Cows.—Much more care should be bestowed in administering food to cows near the time of their reckoning than is generally done. The care should be proportioned to the state of the animal's condition. When in high condition, there is great risk of inflammatory action at the time of parturition. It is therefore the farmer's interest to check every tendency to obesity in time. This may partly be effected by giving fewer turnips and more fodder than the usual quantity; but some cows when in calf, and have been long dry, will fatten on a very small quantity of turnips; and there is a tendency in dry food to aggravate inflammatory action.

Medical Treatment of In-calf Cows.—Other means should therefore be used, along with a limited allowance of food. In as far as medical treatment can be applied to the case, there is perhaps nothing safer than bleeding and laxatives. "Every domestic animal like the cow," observes Skellett, "is to be considered as by no means living in a state of nature. Like man himself, she partakes of civilised life, and of course is subjected to similar infirmities with the human race. The time of gestation is with her a state of indisposition, and every manager of cattle should be aware of this, and treat her with every attention and care during this time. The actual diseases of gestation are not indeed numerous, but they are frequently very severe, and they occasion always a tendency to slinking, or the cow slipping her calf. As the weight of the calf begins to increase, it will then be necessary to take some precautions—and

[1] *Jour. Agric. Soc. Eng.*, i. 167, 168.

these precautions will consist in an attention to her diet, air, and exercise."[1]

Critical Period in Pregnancy.—The eighth and ninth months constitute the most critical period of a cow in calf. The bulk and weight of the fœtus cause disagreeable sensations in the cow, and frequently produce feverish symptoms, the consequence of which is costiveness. The treatment is laxative medicine and emollient drinks, such as a dose of 1 lb. of Epsom salts with some cordial admixture of ginger and caraway-seed and treacle, in a quart each of warm gruel and sound ale. Turnips may be given in moderate quantities, as they have a laxative tendency, especially the white varieties. Potatoes are inadmissible, because of their great tendency to produce hoven. If hoven were to overtake a cow far advanced in pregnancy, the calf would either be killed in the womb, or it would likely cause the cow to abort.

Oilcake for Calving Cows.—Oilcake as a laxative along with swedes is very satisfactory. The cake is given to the cows for two months, one month before and one after calving, and its valuable property of keeping them in a fine laxative state, and at the same time in good health, will be amply demonstrated. The quantity given to each cow daily is usually 2 to 4 lb. at any intermediate time between the feeds of turnips. When a little oilcake is given to cows before and after their calving, less apprehension need be entertained of their safety as far as regards their calving, in whatever condition they may happen to be, as it proves a laxative to the fat, and nourishing food to the lean, cow.

Over-leanness to be avoided.—But the state of over-leanness is also to be avoided in cows in calf. The cow should have nourishing food, such as mashes of boiled barley, turnips, and oilcake, not given in large quantities at a time, but frequently, with a view to laying on flesh in a gradual manner, and at the same time of avoiding the fatal tendency to plethora.

Abortion.

Slinking, abortion, or slipping of the calf, is a vexatious occurrence, and a great loss to the breeder of stock. It is not only a loss of perhaps a valuable calf, but its want makes a blank in the number of the lot to be brought up in the season, which can be filled only by purchase, perhaps not even in that way. Another vexation is that the cow can never again be fully depended upon to bear a living calf, as there will be considerable danger of her slipping in after-years. Why this result should ensue has never been satisfactorily explained. The only safe remedy for the farmer is to take the milk from the cow as long as she gives it, and then fatten her for the butcher.

Causes of Abortion.—The direct causes of this troublesome complaint are various, — chiefly violent exercise, frights, bruises, knocks, bad attendance, diseased bulls, bad food —particularly musty fodder — impure water, bad smells, sympathy, and hay affected with ergot.

Fig. 240.—*Head of timothy with numerous ergots.*

Ergot and Abortion.—There has from time to time been much discussion as to whether or not abortion in cows is due in any large measure to their eating grasses affected with ergot. Ergot is a fungus which attacks the ear or panicle of grasses and cereals, rye particularly, takes the place of the seed, and is recognised there as a black spur. See fig. 240, which represents a head of timothy grass with numerous ergotised ears. Ergot is a strong irritant, and the idea is, that the irritation which ergot consumed in the food by cows sets up in the womb results in the premature expulsion of the fœtus. It is in ergotised hay that the greatest danger exists, for in hay ergot is sometimes present in considerable quantities.

But there is good reason to doubt the contention that ergot is one of the chief causes of abortion amongst cows. It is rarely present in farm crops in such large

[1] Skellett's *Partur. Cow*, 41.

quantities as to be likely to cause abortion. Farmers should certainly regard ergot as a dangerous enemy, and should burn any portions of hay in which it is seen to exist extensively. We suspect, however, that the great majority of the many cases of abortion which occur every year amongst cows must be attributed to other causes.

Bad Smells and Abortion.—Skellett observes: "The cow is remarked to possess a very nice and delicate sense of smelling, to that degree, that the slinking of one cow is apt, from this circumstance, to be communicated to a great number of the same herd; it has been often known to spread like an infectious disease, and great losses have been suffered by the cowfeeders from the same."[1] There is unquestionably much truth in these remarks, and it is therefore desirable that everything in a byre occupied by breeding cows should be kept in a clean and wholesome state. Every particle of filth should be removed daily from the feeding-troughs in front, and the urine-gutters behind the cows, and the byre should be thoroughly ventilated when the cows go out to the courts.

These circumstances also show the propriety of preventing pigs being slaughtered in the court in which cows walk, and any animal being bled near the byre.

Symptoms of Abortion.—The first symptoms of abortion are a sudden filling of the udder before the time of reckoning would warrant, a looseness, flabbiness, and redness of, and a yellow glairy discharge from, the vagina, and a giving way of the ligaments on both sides of the rump.

Preventing Abortion.—Whenever a cow shows symptoms of slinking, which may be observed in the byre, but not easily in the grass field, she should be immediately removed from her companions. She should be narrowly watched, and means of preventing slinking instantly adopted. These consist in keeping her perfectly quiet, giving laxative food, such as oilcake and mashes, and if there is straining, frequent doses of opium, belladonna, or antispasmodics.

But these means will prove ineffectual if the symptoms make their appearance suddenly, and go through their course rapidly.

Mr C. Stephenson on Preventive Means. — Mr Clement Stephenson, M.R.C.V.S., Newcastle-on-Tyne, in a suggestive paper in the *Royal Agricultural Society of England's Journal* (1885), says: "All breeding animals should be kept in as natural a condition as possible. The food should be good in quality, and apportioned according to the breeding state they are in; remember that the fœtus as well as the cow is to be kept in a growing healthy condition. Avoid the practice of giving inferior and refuse food to in-calf cows. Be very particular respecting the purity of the water-supply; neglect of this is a fruitful cause of abortion. See to general sanitary arrangements, ventilation, pure air, and good drainage; use disinfectants freely. In the fields keep a sharp look-out for decomposing putrid matter, which eventually destroy. Exercise is most important; even in winter cows should be let out for a short time every day. Before service be sure that the generative organs of both animals are healthy. Where possible, split up the herd into small lots, cows with bull-calves, cows with heifer-calves, cows and heifers to serve, cows and heifers settled in calf, and doubtful breeders by themselves, which do not serve with a valuable bull, or unless they are regular."

Hemp-seed as a Preventive.—Many American breeders have strong belief in hemp-seed as a safe preventive of repeated abortion in cows that had previously aborted—common hemp-seed, half a pint morning and night about the time of pregnancy at which the cow formerly aborted. Fluid extract of Indian hemp is also commended — a table-spoonful every second day in wet bran, from the time corresponding to former abortion up to within a month of calving. This fluid in excess would itself cause abortion, but in small doses it has a beneficial effect by allaying irritation.

After-risks from Abortion. — The risk which the cow runs, after slinking, is *in not getting quit of the cleansing, afterbirth*, or *placenta*, it not being in a state to separate from the womb. Should it remain, it will soon corrupt, and send

[1] Skellett's *Partur. Cow*, 62.

forth a very nauseous smell, to the detriment of the other cows. If it does not come away in the course of a few hours, or at most a day, the assistance of the veterinary surgeon should be obtained. But in ordinary cases a dose of laxative medicine—such as 1 lb. Epsom salts, 1 oz. powdered ginger, and 1 oz. caraway-seeds—will be quite sufficient.

The cow should have plenty of warm drinks, such as warm water, thin gruel, and mashes made of malt, with bran, so as to keep the body gently open—which should be attended to at all times. Should the regimen not be sufficient to keep the body open, and feverish symptoms appear, recourse must be had to stronger remedies, such as Epsom salts, 1 lb.; nitre, 2 oz.; anise-seed in powder, 1 oz.; cumin-seed in powder, 1 oz.; ginger, ½ oz.;—mixed together for one dose, which is to be given in 2 quarts of water-gruel with ½ lb. of treacle. This dose may be repeated, if the first dose has not had the desired effect, in ten or twelve hours.

Preventing recurrence of Abortion.—In regard to preventing the recurrence of this vexatious complaint, though the best thing for the farmer is not to attempt any, but milk and fatten the cow, yet a natural desire may be felt to retain a valuable and favourite cow, so that means may be used to enable her again to bear a living calf. Skellett mentions as preventive measures, that "when a cow has slipped her calf, in the next gestation she should be early bled, her body should be kept open by cooling physic; she should not be forced to take any more exercise than what is absolutely necessary for her health, and her interfering with other cattle guarded against by keeping her very much by herself. At the same time," he adds, "it must be observed, that though it is necessary to preserve a free state of the bowels, a laxity of them will often produce this accident; cows *fed very much upon potatoes*, and such other watery food, *are very apt to slink*, from their laxative effects. In the food of the cow, at this time, a proper medium should be observed, and it should consist of a due proportion of other vegetable matter mixed with the fodder, so as the bowels may be kept regularly open, and no more."

If the cow is in high condition, she should be reduced in condition; if in very low, she ought to get nourishing food and strengthening medicines; and if she is much annoyed by nauseous smells, these should either be counteracted, or the cow withdrawn from them.

Disinfecting powders and fluids must be sprinkled about the byres—such as Jeyes's fluid, or some preparation of carbolic acid—while washing the backs of the animals themselves with a weak solution of sheep dip or "smear" will tend to counteract any smell or contagion about the animals themselves.

Coarse Pasture causing Abortion.—It is understood that cows which are fed in the neighbourhood of, and in woods, and that live on coarse rank pasture in autumn, are most liable to this complaint. In Switzerland the complaint increases after the cows are put on rank pastures in autumn. Similar experience has been had in this country, where in-calf cows have grazed pastures on which there was a rank growth of coarse herbage, especially after wet sunless years such as 1879. We know of some cases where good has been done by having coarse herbage of this kind cut by a mower in the autumn and gathered into the dung-pit or burned.

Is Abortion Infectious?—Although slinking is spoken of as an infectious complaint, it has no property in common with any contagious disease; and sympathetic influence being a main cause of it, the result is as fatal as if direct contagion had occasioned it.

Calving.

Symptoms of Calving.—About a fortnight before the time of reckoning, symptoms of calving indicate themselves in the cow. The loose skinny space between the vagina and udder becomes florid; the vagina becomes loose and flabby; the lower part of the abdomen rather contracts; the udder becomes larger, firmer, more florid, hotter to the feel, and more tender-looking; the milk-veins along the lower part of the abdomen become larger, and the coupling on each side of the rump-bones looser; and when the couplings feel as if a separation had taken place of the parts there, the cow should be watched day and night, for at any hour afterwards the pains of calving

may come upon her. From this period the animal becomes easily excited, and on that account should not be allowed to go out, or be disturbed in the house. In some cases these premonitory symptoms succeed each other rapidly, in others they follow slowly. With heifers in first calf these symptoms are slow.

Attendance at Calving.—Different practices exist in attending on cows at calving. In the southern counties the cattle-man attends on the occasion, assisted sometimes by the shepherd, and other men if required. In some parts of the northern counties, as also in the south-western counties of Scotland, the calving is left to women to manage. This difference in practice may have arisen from the *degree of assistance* required at the operation. The large and valuable breeds of cows almost always require assistance in calving, the neglect of which might cause the cow to sink from exhaustion, and the calf to be strangled or drowned at its birth. Powerful assistance is sometimes required, and can be afforded only by men, the strength of women being unequal to the task.

The cows of the smaller varieties more frequently calve without assistance, and with these women may manage the calving without difficulty.

On large farms there should be a skilled cattle-man to take the charge, the farmer himself in all cases giving his sanction to the means about to be employed—it being but fair that he himself should bear the heaviest part of the responsibility connected with the process of calving.

Preparation for Calving.—A few preparatory requisites should be at hand when a cow is about to calve. Flat *soft* ropes should be provided on purpose to tie to the calf. The cattle-man should have the calf's crib well littered, and pare the nails of his hands close, in case he should have occasion to introduce his arm into the cow to adjust the calf; and he should have goose-fat or hog's lard with which to smear his hands and arm, although the glairy discharge from the vagina will usually be sufficient for this purpose. Goose-fat makes the skin smoothest. It may be necessary to have a sackful or two of straw to put under the cow to elevate her hind-quarters, and even to have block and tackle to hoist up the hind-legs in order to adjust the calf in the womb. These last articles should be ready at hand if wanted. Straw should be spread thickly on the floor of the byre, to place the new-dropped calf upon. All being prepared, and the byre-door closed for quietness, the cow should be attended every moment.

Progress of Calving.—The proximate symptoms of calving are thus exactly described by Skellett as they occur in an ordinary case. "When the operation of calving actually begins," he says, "then signs of uneasiness and pain appear: a little elevation of the tail is the first mark; the animal shifts about from place to place, frequently getting up and lying down, not knowing what to do with herself. She continues some time in this state, till the natural throes or pains come on; and as these succeed each other in regular progress, the neck of the womb, or *os uteri*, gives way to the action of its bottom and of its other parts. By this action the contents of the womb are pushed forward at every throe; the water-bladder begins to show itself beyond the shape, and to extend itself till it becomes the size of a large bladder, containing several gallons; it then bursts, and its contents are discharged, consisting of the *liquor amnii*, in which, during gestation, the calf floats, and which now serves to lubricate the parts, and renders the passage of the calf easier. After the discharge of the water, the body of the womb contracts rapidly upon the calf; in a few succeeding throes or pains the head and feet of it, the presenting parts, are protruded externally beyond the shape. The body next descends, and in a few pains the delivery of the calf is complete."[1]

Assistance in Calving.—The easy calving here described is usually over in 2 hours, though sometimes it is protracted to 5 or 6, and even to 12 hours, particularly when the water-bladder has broken before being protruded beyond the vagina, and then the calf is in danger of being drowned in the passage. But although the calf may present itself in the natural position, with both its fore-feet projecting, its chin lying on both the fore-legs, and

[1] Skellett's *Partur. Cow*, 105.

the point of the tongue appearing out of the side of the mouth, it may not be calved without assistance. To render this, the feet of the calf being too slippery to be held firmly by the bare hands, the soft flat rope, with a folding loop at the double, is placed above each fetlock joint, and the double rope from each leg is held by the assistants. A pull of the ropes should only be given at each time the cow strains to get quit of the calf. It should be a steady and firm pull, in a direction rather downwards from the back of the cow, and sufficiently strong to retain whatever advance the calf may have made. The assistance given is rather to ease the cow in her exertions in the throes, than to extract the calf from her by force. Meantime the cowman endeavours to relax the skin of the vagina round the calf's head by manipulation, as well as by anointing with goose-fat, his object being to slip the skin over the crown of the calf's head; and when this is accomplished, the whole body may be gently drawn out. In obstinate cases of this simple kind, a looped rope passed across in the mouth round the under jaw of the calf, and pulled steadily, will help the passage of the head; but this expedient should not be resorted to until the cowman cannot effect it with his hands, the cord being apt to injure the tender mouth of the calf.

The Calf.—On the extrusion of the calf, it should be laid on its side upon the clean straw on the floor. The first symptom of life is a few gasps which set the lungs in play, and then it opens its eyes, shakes its head, and sniffs with its nose. The breathing is assisted if the viscid fluid is removed by the hand from the mouth and nostrils. The calf is then carried by two men, suspended by the legs, with the back downwards, and the head held up between the fore-legs, to its comfortably littered crib, where we shall leave it for the present.

Reverse Presentation.—The presentation is sometimes made with the *hind-feet foremost.* At first the hind-feet are not easily distinguished from the fore; but if a hind presentation is made in the natural position of the body, with the back uppermost, the hind-feet will be in an inverted position, with the soles uppermost. There is no difficulty in a hind presentation, only the tail should be put straight, and not folded up, before the legs are pulled out. The first obstructing point in this presentation is the rump, and then the thickest part of the shoulder. On drawing out the head, which comes last, it should be pulled away quickly, in case the calf should give a gasp for air at the moment of leaving the cow, when it might inhale water instead of air, and run the risk of drowning. The mouth and nose should, in this case, be wiped immediately on the calf being laid down upon the straw on the floor.

Restless Cows in Calving.—All as yet has been easily managed, and so will be as long as the cow lies still on her side in the stall, with plenty of straw around and behind her hind-quarter. But some cows have a restless disposition, and, whenever the pains of labour come on, start to their feet, and will only lie down again when the pain ceases. It is thus scarcely possible to ascertain the true position of the calf, especially when not presented in a natural position. It is now necessary to extract the calf energetically, and remove the uneasiness of the cow quickly; for until she gets quit of the calf, she will not settle in any one position. When the calf is so near the external air as to enable the operator to get the ropes round its legs, whether fore or hind, they should be fastened on immediately after the discharge of the water, and, on gently pulling them, her attention will be occupied, and she will strain with great vigour, the standing position giving her additional power, so that the extraction of the calf is expeditious.

As the calf will fall a considerable height, the ground should be well littered, so as to receive the body of the calf upon it. Active means should be used after the symptoms of actual calving have begun. If such are neglected, the calf may be found killed, or injured for life.

Reviving Calves.—Some calves, though extracted with apparent ease, appear as if dead when laid upon the straw. Besides removing the viscid fluid from the mouth and nose, the hand should be placed against the side of the breast, to ascertain if the heart beats. If it does so, all that is wanted is to inflate the lungs. To do this the mouth should be opened, and if no breathing is yet felt,

some one should blow steadily into the mouth, a device which seems to answer the purpose; and also a hearty slap of the open hand upon the buttock of the calf will cause it to start, as it were, into being. Perhaps bellows might be usefully employed in inflating the lungs. Should no beating of the heart be felt, and yet consciousness of life seem to exist, the calf should be carried without delay to its crib, and covered up with the litter, leaving the mouth free to breathe, and it may survive. But even after a few gasps it may die—most probably the cause of death arising from injury received in calving, such as too long detention in the vaginal passage, or a too severe squeeze of the womb on the thorax, or by the rashness of the operator.

Dead Calf.—When a calf is thus lost, its body should be skinned while warm, cut in pieces, and buried in a compost for manure, and the skin sold or made into "wechts" or baskets for the corn-barn.

Difficult Presentations.—The difficult cases of presentation which usually occur are with one foot and the head, and the other foot drawn back, either with the leg folded back altogether, or the knee doubled and projecting forward. In all these states the missing leg should be brought forward. To effect this, it is necessary to put round the presented foot a cord to retain it within the power of the operator, and the head is then pushed back into the womb to make room to get at the missing foot, to search for which the greased arm of the operator should be introduced, and the foot gently brought beside the other. The rope which was attached to the first foot now serves to pull the entire body into the passage, when the throes may again be expected to be renewed.

The presentation may be of the head alone without the feet, which may be knuckled forward at the knees, or folded back along both sides. In the knuckled case both legs should be brought forward by first pushing the head back, and, in case of losing hold of the calf, a loop of rope should be put in the calf's mouth: in the folded case, both should be brought forward.

A worse case than either is, when one or both legs are presented and the head folded back upon the side. In this case the calf will most likely be dead. The legs should be pushed back, retaining hold of them by ropes, and the head brought forward between the legs if possible. It may be beyond the strength of the operator to bring forward the head; if so, he should put a loop into the calf's mouth, and his assistants pull forward the head by it.

Still more difficult cases may occur, such as a presentation of the shoulder, with the head lying into the side; a presentation of the buttock, with both the hind-legs stretched inwards; or the calf may be on its back, with one of the worst presentations now enumerated,

In whichever of these positions the calf may present itself, no extraction can safely take place until the head, and one of the legs at least, are secured, or both the hind-legs, with the back turned uppermost, are presented. In no case should a fore or hind leg be so neglected, as to either obstruct the body on passing through, or tear the womb of the cow. The *safest* practice is, to secure both legs as well as the head. This may cause the operator considerable trouble, but by retaining hold of what parts he can with the cords, and dexterously handling the part amissing, so as to bring it forward to the passage whilst the assistants pull as he desires, his object will in most cases be attained. But it should be borne in mind that none of these objects will be attained without the powerful assistance of the throes of the cow herself. If this precaution is not attended to and watched for by the operator, the muscular grasp of the womb will render his arm powerless.

One circumstance should here be considered by the operator. When the hind-quarters of the cow have an inclination downwards, she has the power to strain the stronger, and to counteract his efforts the more easily. On finding her position so, he should raise the hind-quarters of the cow with sackfuls of straw higher than the fore-quarters, until he has got the calf in the position he desires, and then, on letting the cow down again, and watching her strainings, assist her at that time and only at that time, and the extraction may be successful.

But the power of the womb may

have been exhausted. When it can no longer render assistance by its strainings, the operator must continue his exertion with the greater force until the calf is brought away. When the head only of the calf is presented, and cannot protrude itself through the vagina, an inspection should be made of the position of the calf, by thrusting the head back with a loop in the mouth, and on finding the fore-legs bent backward, to bring them forward. When this inspection has been too long delayed, and the head kept confined in the passage, the violent throes of the cow will most likely strangle the calf, and the head will swell to an inordinate degree. The swelling will prevent the calf's head from being pushed back to get at the legs, then the head must be cut off, the legs brought forward, and the body extracted.

One of the most difficult cases is, when the fore-feet are presented naturally, and the head is thrust down upon the brisket between the legs. The feet must first be pushed back, and the head brought up and forward, when the extraction will become natural.

Extracting a Dead Calf.—When the symptoms of calving have continued for a time, and no appearance of a presentation by the calf, the operator should introduce his arm to ascertain the cause, and the probability will be that the calf has been dead in the womb some time. A dead calf is easily recognised by the hand of an experienced cowman. It should be extracted in the easiest manner; but should the body be in a state of decay, it will not bear being pulled out whole, and must be taken away piecemeal.

Twin Calves.—As regards the extraction of twin calves, before rendering the cow any assistance it is necessary to ascertain whether there are twins, and that the calves have made a proper presentation; that they are free of each other; that one member of the one is not interlaced, or presented at the same time with any member of the other. When quite separated, each calf may be treated according to its own case.

Desperate Cases.—The block and tackle should never be resorted to but to save the life of the cow. If this might be done by turning the calf, the attempt should be made in the best manner. If this is not likely to succeed, it will be better to destroy the calf by cutting it away than lose the cow. Should the cow die, the live calf can easily be extracted by the Cæsarean operation.

Veterinary Advice in Calving.—A skilful cowman may be able to manage all these difficult cases within a reasonable time; but unless he is particularly dexterous at cases of calving, it is much safer to work under the advice of a veterinary surgeon, who may or may not operate himself. In the case of extracting monstrosities, his actual assistance is indispensable.

Isolation in Difficult Cases.—Calving in a byre does not seem to produce any disagreeable sensations in the other cows, as they express no surprise or uneasiness in regard to what is going on beside them. When the cow gives vent to painful cries, which rarely happens, the others express a sympathetic sound; and when the calf is carried away, they exhibit some restlessness, but the emotion arising therefrom soon subsides. But if difficult and protracted labour is apprehended, it is better for the other cows, and also for the particular cow herself, that she be removed to another well-littered apartment, where the operator and his assistants can have free action around her.

Mistaken Idea.—A notion exists in some parts of England that a cow, when seized with the pains of labour, should be made to move about, and not allowed to lie still, although inclined to be quiet. "This proceeds from an erroneous idea," Skellett well remarks, "that she will calve much easier, and with less danger; but so far from this being the case, the author has known a great many instances where the driving has proved the death of the animal by overheating her, and thus producing inflammation and all its bad consequences. Every rational man will agree in opinion with the author, that the above practice is both cruel and inconsistent in the extreme; and this is confirmed by what he has noticed, that the animal herself, as soon as the pains of calving come on, immediately leaves the rest of the herd, and retires to some corner of the field, or under a hedge, in order to prevent

the other cows, or anything else, coming near, that may disturb her in bringing forward her young."[1]

Quietness for Cows at Calving.—In short, too much gentleness cannot be shown to cows when calving, and they cannot be too strictly guarded against every species of disturbance.

Afterbirth.—The afterbirth, or placenta, does not come away with the calf, a portion of it being suspended from the cow. It is got quit of by the cow on straining, and when the calving has been natural and easy, it seldom remains longer than from one to seven hours. In bad cases of labour it may remain longer, and may only come away in pieces; but when it remains too long and is sound, its separation will be assisted by attaching a small weight to it, say of 2 lb., with the occasional straining of the cow.

A draught in gruel, containing Epsom salts 8 ounces, powdered ergot 1 ounce, and carbonate of ammonia 4 drachms, given daily, will facilitate the cleansing. If the afterbirth should remain till decomposition actually commences, the hand should be introduced and the placenta removed as gently as possible.

The common custom is to throw the afterbirth upon the dunghill, or to cover it up with the litter; but it should not be put there to be accessible to every dog and pig that may choose to dig it up—pigs have been known almost to choke themselves with it. Let the substance be buried in a compost-heap; and if there be none such, in the earth. The umbilical cord or *navel-string* of the calf breaks in the act of calving.

Refreshing the Cow.—When a cow seems *exhausted* in a protracted case of calving, she should be supported with a warm drink of gruel, containing a bottle of sound ale. Should she be too sick to drink it herself, it should be given her with the drinking-horn.

After the byre has been cleansed of the impurities of calving, and fresh litter strewed, the cow naturally feels thirsty after the exertion, and should receive a warm drink. There is nothing better than warm water, with a few handfuls of oatmeal stirred in it for a time, and seasoned with a handful of salt. This she will drink up greedily. A pailful is enough at a time, and it may be renewed when she expresses a desire for more. This drink should be given to her for two or three days after calving in lieu of cold water, and mashes of boiled barley and gruel in lieu of cold turnips; but the oil-cake should never be forgotten, as it acts at this critical period as an excellent laxative and febrifuge.

Barley for newly Calved Cows.—A common practice with some is to give the cow barley in the sheaf to eat, and even raw barley, when there is no barley in the straw. Sometimes a few sheaves are kept for the purpose; and barley-chaff is given where people grudge to part with good barley in this way. The practice, however, is objectionable, for nothing causes indigestion more readily than raw barley or barley-chaff at the time of calving, when the tone of the stomach is impaired by excitement or fever. *Boiled* barley, with a mucilaginous drink, is quite safe.

Nothing should be given at this time of an astringent nature. The food should rather have a laxative tendency.

Immediate Milking.—It is desirable to milk the new-calved cow as soon as convenient for her, the withdrawal of milk affording relief. It frequently happens that an uneasiness is felt in the udder before calving; and should it increase while the symptoms of calving are yet delayed, the cow will experience much inconvenience, especially if the flush of milk has come suddenly.

The Udder.—The cause of uneasiness is unequal hardness of the udder, accompanied with heat, floridness, and tenderness. Fomentation with warm water twice or thrice a-day, continued for half an hour at a time, followed by gentle rubbing with a soft hand and anointing with goose-fat, will tend to allay irritation. In the case of heifers with the first calf, the uneasiness is sometimes so great during the protracted symptoms of calving, as to warrant the withdrawal of milk before calving.

Should the above remedial measures fail to give relief, the great heat may cause direct inflammation and consequent suppuration in the udder. To avert such an issue, the uneasiness should be attend-

[1] Skellett's *Partur. Cow*, 113.

ed to the first moment it is observed, neglect permitting the complaint to proceed so far as to injure the structure of the udder. Prevention of the congestion of the udder may be secured by refraining to give rich food until after the ninth day, when the womb has discharged its contents attendant on calving.

Attention to the Cow.—In ordinary cases of calving, little apprehension need be felt for the safety of the cow; but she must be carefully attended to for at least a fortnight after calving. No cold drinks, no cold turnips, should be given her, and no cold draughts of air allowed to blow upon her. The hind-quarters, raised up by litter for a few days, will recover the tone of the relaxed parts.

Flooding.—In cases of severe and protracted labour the cow may be overtaken by several casualties, such as flooding or loss of blood, which is caused by the vessels of the womb being prevented collapsing as they should do; but it is not often a fatal complaint, and may be removed by the application of a lotion, consisting of a quart of strong vinegar mixed in one gallon of spring-water, in which cloths should be dipped, and applied frequently to the loins, rump, and vagina. A drink of two quarts of cold water and a pint of ale will much relieve her and assist the efforts of nature.

Protruding Womb. — Should the womb protrude when the placenta remains too long after delivery, in consequence of long and severe straining of the cow, the womb should be washed perfectly clean with a mixture of milk and warm water, and replaced with care, taking hold of it only by the upper side. The hind-quarter of the cow should be well elevated with straw, and a saline dose of laxative medicine administered, with some opium, to allay pain and prevent straining.

Inflammation in the Womb.—After severe calving, draughts of cold air may cause inflammation in the womb. Large drinks of cold water will produce the same effect, as well as the irritation arising from retention of the cleansing. A purge is the safest remedy, consisting of 1 lb. of Epsom salts, 8 drachms powdered aloes, and ½ ounce ginger in a quart of warm water or gruel.

But in all cases of severe calving the veterinary surgeon should witness the process, and afterwards administer the requisite medicines and prescribe the proper treatment and regimen.

Uterine Discharge. — About nine days after calving, should no uterine discharge come from the cow, means should be used to promote it, otherwise severe costiveness and puerperal fever may ensue. Oilcake for a fortnight before and after calving has been found an excellent expedient for promoting the discharge—which discharge has the effect of thoroughly cleansing the womb.

Coming in "Season."—A cow will desire the bull in four or five weeks after calving. The symptoms of a cow being in season are thus well described by Skellett: "She will suddenly abate of her milk, and be very restless; when in the field with other cows she will be frequently riding on them, and if in the cow-house she will be constantly shifting about the stall; her tail will be in constant motion; she will be frequently dunging, staling, and blaring; will lose her appetite; her external parts will appear red and inflamed, and a transparent liquor will be discharged from the vagina. In old cows these symptoms are known to continue 4 or 5 days, but in general not more than 24 hours, and at other times not more than 5 or 6 hours. Therefore, if a cow is intended for procreation, the earliest opportunity should be taken to let her have the bull; for if it be neglected then, it will often be 2 or 3 weeks before the above symptoms will return. These instructions," adds Skellett, "are necessary to be given only to the proprietor of a small number of cows, where a bull is not always kept with them. . . . If a cow, after calving, shows symptoms of season sooner than 4 or 5 weeks, which is sometimes the case, she should *not be permitted to have the bull sooner than 4 or 5 weeks from that period*—for the womb before that time is, in general, in so relaxed a state, as not to be capable of retaining the seed, consequently she seldom proves with calf if she is suffered to take him sooner."[1]

Too Early Bulling Unwise.—This last remark is of great value, for there is

[1] Skellett's *Partur. Cow*, 11-13.

good reason to believe that many cases of cows not holding in calf with the first serving after calving arises from the want of consideration on the part of breeders as to whether the cow is in that recovered state from the effects of calving which may be expected to afford a reasonable hope that she shall conceive. And this is a point more to be considered than the mere lapse of time after calving; for a cow, after a severe labour, may be in a much worse state for conception, even at double the length of time, than another which has calved with ease, although she may have come as regularly into season as her more fortunate neighbour. The state of the body, as well as the length of time, should be taken into consideration in determining whether or not the cow should receive the bull.

Fatigue affecting Pregnation.—A common practice in places where there is no bull, is to take the cow to the bull at a convenient time for the cattle-man to take her; and should she have passed the bloom of the season before her arrival at the bull, the issue will be doubtful. The cow may have travelled a long distance and become weary, and no rest has been allowed her, although she has to undergo the still farther fatigue of walking home. Fatigue renders impregnation doubtful. Many are not satisfied with the service of their cows until both bull and cow are wearied out. Others force cow or bull, holding her by the nose, and goading him with a stick against the inclination of either. Such treatment renders impregnation doubtful. There is, beside, the chance that the bull is worn out for the day.

None of these mischances can happen when a bull is at home. Even then a discretion is requisite to serve the cow at the proper time, and this can only be known by observing her state.

Cow's Record of Character.—It is desirable that the farmer should keep or have kept a record of the character of each cow, in regard to her state of season, and of her reckoning to calve—a desirability all the greater because of the great difference of character evinced by cows under the same treatment. For example, one arrives soon at mature season after the symptoms are exhibited, and as soon it disappears; a second requires some hours to arrive at the same point, and the season continues for a time in a languid state: a third runs through the course of season in a few hours, while a fourth is only prepared to receive the bull at the last period of her season; a fifth may exhibit great fire in her desire, which induces her keeper to have her served at once, when too soon; whilst a sixth shows comparative indifference, and, in waiting for an exhibition of increased desire, the season is allowed to pass away; and in this last case, cattlemen, conscious of neglect, and afraid of detection, will persist in the bull serving her, though she may be very much disinclined, and does everything in her power to avoid him.

Attention in Serving.—There is no way so natural for a bull to serve a cow, as when both are in the field together. The most proper time is chosen by both, and failure of conception then rarely happens. But it is possible that the bull cannot serve the cow in the field by disparity of height. The cow should then be taken to a part of the ground which will favour his purpose. One *thorough* skip is quite sufficient for securing conception, but two or three skips are mostly insisted upon. The cow should be kept quiet in the byre after being served until the desire leave her, and she should have no food or water for some hours after, as any encouragement of discharges from the body, by food and drink, is inimical to the retention of the semen.

Conception Completed. — "When nature is satisfied," says Skellett, "or the symptoms of season disappear in the animal, conception has taken place. The neck of the womb becomes then completely closed by a glutinous substance which nature has provided for that purpose, being perfectly transparent, and with difficulty separated from the parts. This matter is for the purpose of excluding all external air from the mouth of the womb during gestation, which, if admitted to the fœtus, would corrupt the membranes and the pellucid liquor in which the fœtus floats, and would undoubtedly cause the cow to slink. This glutinous substance also prevents the lips of the mouth of the womb from growing together; and when the cow comes into season it becomes fluid—the

act of copulation serving to lubricate the parts and prevent inflammation."[1]

In-Calf Heifers.—The heifers in calf that are to be transferred to the cow-stock should be taken from their hammels, in which they have been all winter, into the byre, into the stalls they are to occupy, about three weeks or a fortnight before their reckoning. If they had been accustomed to be tied by the neck when calves, they will not feel much reluctance in going into a stall; but if not, they will require some coaxing to do it. When taking them to the byre at first, it should be remembered that a fright received at this juncture may not be forgotten by them for a long time to come. To avoid every chance of that, let them go in quietly of their own accord; let them snuff and look at everything they wish; and having assistants to prevent their breaking away, let the cattle-man allow them to move step by step, until they arrive at the stalls. Here may be some difficulty: some favourite food should be put in the manger to entice them to go up. Another difficulty will be putting the seal, fig. 104, round the neck. It should be hung, when not in use, upon a nail on the stake, from which it should be quietly taken down, without clanking the chain; and while the heifer is eating, let the cattle-man slip one hand below the neck with the chain, while the other is passed over it, to bring the loose end of the seal round the neck, and hook it into whatever link he first finds. The moment the heifer feels she is bound, she will hang back, or attempt to turn round in the stall to get away, which she should be prevented doing by gentle means; and after remaining in that state for some time, and feeling herself well used and kindly spoken to, she will yield; but although she may appear to submit, she must not be left alone for some time—till the assurance she will not attempt to turn in the stall is certain.

Reckoning Table.—The following table, containing the dates at which cows should calve from those at which they were bulled, is founded upon the data afforded by Lord Spencer—namely, 285 days as the average period of gestation. It is unnecessary to fill up the table with marking down every day of the year, as in the short period between each fortnight can easily be calculated the particular reckoning of each cow:—

A RECKONING TABLE FOR THE CALVING OF COWS.

When Bulled.	When will Calve.	When Bulled.	When will Calve.
Jan. 1.	Oct. 13.	July 16.	April 27.
" 15.	" 27.	" 30.	May 11.
" 29.	Nov. 10.	Aug. 13.	" 25.
Feb. 12.	" 24.	" 27.	June 8.
" 26.	Dec. 8.	Sept. 10.	" 22.
March 12.	" 22.	" 24.	July 6.
" 26.	Jan. 5.	Oct. 8.	" 20.
April 9.	" 19.	" 22.	Aug. 3.
" 23.	Feb. 2.	Nov. 5.	" 17.
May 7.	" 16.	" 19.	" 31.
" 21.	March 2.	Dec. 3.	Sept. 14.
June 4.	" 16.	" 17.	" 28.
" 18.	" 30.	" 31.	Oct. 12.
July 2.	April 13.		

Leading Cows.—A cow is generally easily led to the bull at a distance by a halter round the head. If she is known to have a fractious temper, it is better to put a holder in her nose than to allow her to run on the road and have to stop or turn her every short distance. A simple form of holder is in fig. 241, which has a joint that allows the two parts of the holder to meet, and to open so far asunder as to embrace the nostril of the animal. A screw-nut brings the two knobbed points as close as to embrace firmly the septum of the nose. In using this nut it should not be so tightly screwed as to squeeze the septum. The leading-rein is fastened to the under ring.

Fig. 241.—*Bullock-holder.*
a Joint.
b Knobbed points, meeting.
c Screw-nut.
e Ring for rein-rope.

In Africa "an unruly cow is never tied by the head: a man walks behind it, having hold of a rope tied tightly round its hock; this plan seems to *Rareyfy* the animal most completely."[2]

Detecting Pregnancy.—The usual mode of determining whether a cow is in calf is deceptive. She may not have held when bulled; she may

[1] Skellett's *Partur. Cow*, 17.

[2] Grant's *Walk across Africa*, 52.

have taken the bull again in a few days, and she may not show evident symptoms of calving until only a few days before she actually calves. The application of the ear to the flank of the cow is a simpler and more certain mode of ascertaining the pulsation of the calf, and the unerring *stethoscope* renders the mode truly philosophical. The existence of pregnancy may be detected by it at as early a stage as six or eight weeks, by which time the beating of the heart of the calf may be distinctly heard, and its singular double beating cannot be mistaken.

Milk-fever.—"Although parturition is a natural process," as is well observed by Youatt, "it is accompanied by a great deal of febrile excitement. The sudden transferring of powerful and accumulated action from one organ to another—from the womb to the udder—must cause a great deal of constitutional disturbance, as well as liability to local inflammation."[1] One consequence of this constitutional disturbance of the system is *milk-fever* or puerperal fever. Cows in high condition are more subject than others to this complaint, and especially if they have been kept up for some weeks before calving. The complaint may seize the cow only a few hours after calving, or it may be days. Its first attack is probably not observed by those who have the charge of the cows, or even by the farmer himself, who is rather chary in looking after the condition of cows, in case he should offend his female friends, to whose special care that portion of his stock is consigned.

The *symptoms* are first known by the cow shifting about in the stall, or from place to place if loose, lifting one leg and then another, being easily startled, and looking wildly about her as if she had lost her calf, and lowing for it. Then the flanks begin to heave, the mouth to open and issue clear water, she staggers in her walk, and at length loses the use of her limbs, lies down and places her head upon her side. The body then swells, the extremities feel cold and clammy. Shivering and cold sweats follow, the animal is at first wild and excited, throwing her head about, and afterwards comatose; the pulse becomes irregular, and death ensues.

The promptest *remedy* to be used, after the first symptom has been observed, is to bleed to the extent of 3 or 4 quarts, but not after the earliest stages. The next is to open the bowels, which will be found to have a strong tendency to constipation. From 1 lb. to 1½ lb. of Epsom salts, according to the strength of the cow, with a little ginger and caraway, should be given as a purge. The spine should be stimulated by the application of ammonia liniment, and the head kept cool by cloths wet with cold water. The animal should be bolstered up into the natural position with bundles of straw, and hoven prevented by the use of the trocar and canula. Perspiration must be induced by covering with cloths, and the animal must be prevented from injuring herself when she begins to throw her head wildly about. It must be confessed, however, that the disease is nearly always fatal. Treatment rarely effects a cure, and practical experience has shown that, in the majority of cases, it is much better to kill the animal at once, as she is sure to die at any rate.

Prevention of Milk-fever.—But it is a preventable disease. It is due to overfeeding and having the body in a too plethoric state from the use of concentrated foods. Regular physicking and moderate feeding for a month or so before calving, so as to reduce any "fulness" of body, will almost always ensure safety.

Red-water.—The ninth day after a cow has calved, a uterine discharge should take place, and continue for a day or two, after which the cow will have all the symptoms of good health. It has been observed that when this discharge does not take place, the cow will soon after show symptoms of *red-water*. She will evacuate urine with difficulty, which will come away in small streams, and be highly tinged with blood, and at length appear like dark grounds of coffee. "The nature and cause of the disease are here evident enough," as Youatt well observes. "During the period of pregnancy there had been considerable determination of blood to the womb. A degree of susceptibility, a tendency to inflammatory action had been set up, and this had been increased as the period of parturi-

[1] Youatt's *Cattle*, 546.

tion approached, and was aggravated by the state and general fulness of blood to which she had incautiously been raised. The neighbouring organs necessarily participated in this, and the kidneys, to which so much blood is sent for the proper discharge of their function, either quickly shared in the inflammation of the womb, or first took an inflammation, and suffered most by means of it." [1]

The *prevention* of this disease is recommended in using purgative medicine after calving; but as purging never fails to lessen the quantity of milk given by the cow for some time after, a better plan is to give such food as will also operate as a laxative for some time before as well as after calving. One substance which possesses these properties is *oilcake*.

MILKING COWS.

Structure of the Udder.—The structure of a cow's udder is remarkable. It consists of two glands, disconnected with each other, but contained within one bag or cellular membrane; these glands being uniform in structure. Each consists of three parts, the *glandular* or secreting, the *tubular* or conducting, and the *teats* or receptacle or receiving part. The division is longitudinal, and each half is provided with three teats, one of which, however, is abortive, so that milk is only yielded by four altogether, and thus each teat with its adjacent portion of the udder is called a "quarter." The glandular forms much the largest portion of the udder. It appears to the naked eye composed of a mass of yellowish grains, but under the microscope these are found to consist entirely of minute blood-vessels forming a compact plexus, which secrete the milk from the blood.

The udder should be capacious, though not too large for the size of the cow. It should be nearly spherical in form, though rather fuller in front, and dependent behind. The skin should be thin, loose, and free from lumps, filled up in the forepart of the udder, but hanging in folds in the hind part. Each quarter should contain about equal quantities of milk, though sometimes the hind ones yield the most.

[1] Youatt's *Cattle*, 504.

The teats should be at equal distances every way, neither too long nor too short, but of moderate size, and equal thickness from the udder to the point, which should be smaller. They should not be too large at the udder, to permit the milk to flow down too freely from the bag and lodge in them; nor too small at that place, to allow the coagulation of the milk to *cord up* or fill the orifice; nor too broad at the point, to have the orifice so large that the cow cannot retain her milk after the bag becomes full and heavy. They should be smooth, and feel like velvet, firm and soft to handle, not hard and leathery. They should yield the milk freely, and not require to be forcibly pulled.

When the milk is first to be taken from the cow after calving, the points of the teats will be found plugged up with a resinous substance, which, in some instances, requires some force to be exerted on them before it will yield.

First Milk.—The milk that is obtained for the first four days has a thick consistence, and is of a yellow colour. It is known as the "colostrum," and has obtained the name of *biestings* in Scotland. It possesses the coagulable properties of the white of an egg, and will boil into a thick substance called biesting cheese. But it is seldom used for such a purpose, and is given to the calf, because in many parts the people have a notion that it is not wholesome to use the biestings.

Theory of Milking.—"Thus, then," says a writer, "we perceive that the milk is abstracted from the blood in the glandular part of the udder; the tubes receive and deposit it in the reservoir or receptacle; and the contractile tissue at the end of the teat retains it there till it is wanted for use. But we must not be understood to mean, that all the milk drawn from the udder at one milking, or *meal*, as it is termed, is contained in the receptacle. The milk, as it is secreted, is conveyed to the receptacle, and when this is full, the larger tubes begin to be filled, and next the smaller ones, until the whole become gorged. When this takes place, the secretion of the milk ceases, and absorption of the thinner or more watery part commences. Now, as this absorption takes place more readily in the smaller or more distant tubes, we invariably find that the milk from these, which comes

the last into the receptacle, is much thicker and richer than what was first drawn off. This milk has been significantly styled *afterings;* and should this gorged state of the tubes be permitted to continue beyond a certain time, serious mischief will sometimes occur: the milk becomes too thick to flow through the tubes, and soon produces, first irritation, then inflammation, and lastly suppuration, and the function of the gland is materially impaired or altogether destroyed. Hence the great importance of emptying the smaller tubes regularly and thoroughly, not merely to prevent the occurrence of disease, but actually to increase the quantity of milk; for so long as the smaller tubes are kept free, milk is constantly forming; but whenever, as we have already mentioned, they become gorged, the secretion of milk ceases until they are emptied. The cow herself has no power over the tissues at the end of the teat, so as to open and relieve the overcharged udder: neither has she any power of retaining the milk collected in the reservoirs when the spasm of these is overcome."[1]

Thus the necessity of drawing away the last drop of milk at every milking; and the greater milker the cow is, this is the more necessary.

Hefting.—Thus also the impropriety of *hefting* or holding the milk in cows until the udder is distended much beyond its ordinary size, for the sake of showing its utmost capacity for holding milk, a device which all cow-dealers, and indeed every one who has a cow for sale in a market, scrupulously adopts. It is remarkable that so hackneyed a practice should deceive any one into its being a measure of the milking power of the cow; for every farmer is surely aware that, when he purchases a hefted cow, he gains nothing by the device. Why, then, encourage so cruel and injurious a practice in dealers? Were purchasers to insist on a reduction in price of the cow that is hefted, the dealers would be obliged to relinquish the bad practice.

Indications of Milking Properties.—The milking properties of a cow are to a certain extent indicated by what is called a large *milk-vein* below the belly. This vein is the subcutaneous vein, and drains a part of the udder of its blood, and when large, certainly indicates a strongly developed vascular system, which is favourable to secretion generally, and no doubt that of milk in particular.

Milk-pails.—The vessel used for receiving the milk from the cow is simple, as in fig. 242, which is one of the most convenient form. The size may be made to suit the dairymaid's taste. It is made of thin oak staves bound together with three thin galvanised hoops. Pails similar in shape are now made of tinned iron, and are preferable for cleanliness and lightness. Pitchers of tin are mostly used for milking in the dairies of towns. In Holland the milking-pails are made of brass, and must be kept quite bright, otherwise they would injure the milk. The Dutch dairymaids have a great deal of trouble in keeping these vessels in proper order. A pail, as fig. 242, is of a convenient size when 9 inches in diameter at the bottom, 11 inches at the top, and 10 inches deep, with a handle 5 inches high; which dimensions will give a mouth capacious enough to receive the milk as it descends, and of a sufficient height to rest on the edge of its bottom when held firmly between the knees of the milker, as he or she sits upon the three-legged stool. The pail should not be milked quite full for fear of spilling, and should be large enough to contain all the milk that a cow will give at a milking, as it is undesirable to annoy the cow by rising from her before the milking is finished, or by exchanging one pail for another.

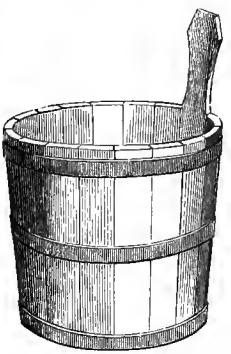


Fig. 242.—*Milk-pail.*

The milking-stool, as in fig. 243, is made of ash, to stand 9 inches in height, or any other height to suit the convenience of the milker, with the top 9 inches in diameter, and the legs a little spread

[1] Blurton's *Prac. Ess. Milk.*, 6, 7.

out below to give the stool stability. Some milkers do not care to have a stool, and prefer sitting on their haunches; but a stool keeps the body steady, and the

Fig. 243.—*Milking-stool.*

arms have more freedom to act, and ready to prevent accidents to the milk in case of disturbance by the cow.

Cows holding back Milk.—The cow, being a sensitive and capricious creature, is so easily offended that, if the milker rise from her before the milk is all withdrawn, the chances are she will not again stand quietly at that milking; or if the vessel used in milking is taken away before the milking is finished, and another substituted in its place, the probability is that she will *hold* back her milk—that is, not allow it to flow. This is a curious property which cows possess, and how it is effected is not very well understood; but there is no doubt of the fact occurring when a cow becomes irritated or frightened by any cause.

All cows are not affected to the same degree; but, as a proof of their extreme sensitiveness in this respect, it may be mentioned that very few can be milked so freely by a stranger the first time as by one to whom they have been accustomed.

The Milking Side.—Usually, the near side of the cow is taken for milking, and it is called the *milking side;* but whichever side is adopted, that should always be used with the same cow. The near or left side of the cow may have been adopted for two reasons; because we are accustomed to approach all the larger domesticated animals by the *near side*—the animal's left side—as being the most convenient for ourselves; and because most people are right-handed, and thereby the right hand being the stronger, it is most conveniently employed in milking the hinder teats of the cow, which are most difficult to reach, because of the position of the hind part of the udder between the hind-legs. The near side is most common in Scotland, while in England the other side is preferred. It is rare to see a cow milked in Scotland by any other than a woman, though men commonly do it in England.

The Operation of Milking.—Milking is performed in two ways, stripping and nievling. *Stripping* consists of seizing the teat firmly near the root between the front of the thumb and the side of the forefinger, the length of the teat lying along the other fingers, and of pressing the finger and thumb while passing them down the entire length of the teat, and causing the milk to flow out of its point in a forcible stream. The action is renewed by again quickly elevating the hand to the root of the teat. Both hands are employed at the operation, each having hold of a different teat, and moving alternately. The two nearest teats, the fore and hind, are first milked, and then the two farthest.

Nievling is done by grasping the teat with the whole hand, or *fist*, making the sides of the forefinger and thumb press upon the teat more strongly than the other fingers, when the milk flows by the pressure. Both hands are employed, and are made to press alternately, but so quickly in succession that the alternate streams of milk sound on the ear like one forcibly continued stream; and although stripping also causes a continued flow, the nievling, not requiring the hands to change their position, as stripping does, draws away the larger quantity of milk in the same time.

Stripping is thus performed by pressing and passing certain fingers along the teat; nievling by the doubled *fist* pressing the teat steadily at one place.

Of the two modes we prefer the *nievling*, because it is more like the sucking of a calf. When a calf takes a teat into its mouth, it seizes it with the tongue against the palate, causing them to play upon the teat by alternate pressures or pulsations, while retaining it in the same position. Nievling does this; but the action of stripping is quite different.

It is said that stripping is good for agitating the udder, and agitation is conducive to the withdrawal of a large quantity of milk; but there is nothing to prevent the milker agitating the udder while holding the teats in nievling —indeed, a more constant agitation is really kept up by the vibrations of the arms, than by pulling the teat constantly down as in stripping.

Stripping, by using a strong pressure upon two sides of the teat, is more likely to press it unequally than by grasping the whole teat in the palm of the hand; while the *friction* occasioned by passing the finger and thumb firmly over the skin of the teat, is also more likely to excite heat and irritation in it than a grasp of the hand. This friction causes an unpleasant feeling even to the milker, who is obliged to lubricate the teat frequently with milk, and to wet it at first with water, whereas nievling requires no such expedients; and as it gives pain to the cow, it cannot be employed when the teats are chapped, or affected with cow-pox, while nievling can be used with impunity.

Milking should be done *fast*, to draw away the milk as quickly as possible; and it should be continued as long as there is a drop of milk to bring away. This is an issue which the dairymaid cannot too particularly attend to herself, and see it in her assistants. Old milk left in the receptacle of the teat soon changes into a curdy state; and the caseous matter, not being at once broken and removed by the next milking, is apt to irritate the lining membrane of the teat during the operation, especially when the teat is forcibly rubbed down between the finger and thumb in stripping. The consequence of this irritation being repeated is a thickening of a part of the lining membrane, which at length becomes so hardened as to constitute a stricture which at length closes up the orifice of the teat. The stricture may easily be felt from the outside of the teat, and the teat is then said to be *corded*. After this the teat becomes "deaf" or "blind," and no more milk can afterwards be drawn from the quarter of the udder with which the corded teat communicates.

Cows troublesome at Milking.—Cows are often troublesome on being milked; and the kicks and knocks which they receive for their restlessness only render them the more fretful. If they cannot be overcome by kindness, thumps will never make them better. But the fact is, restless habits were engendered in them by the treatment they received when first taken into the byre, when, most probably, they were dragooned into submission. Udders and teats are very tender immediately after calving, and especially after the first calving; and when unfeeling horny hands tug the teats in *stripping*, as if they had been accustomed to the operation for years, no wonder that the young and inexperienced cow should wince under the infliction, and attempt by kicking to get quit of her tormentor. Can the creature be otherwise than uneasy? and how can she escape the pain but by striking out a heel? The hobbles are then placed on the hind-legs, to keep the heels down. The tail is next employed by her as an instrument of annoyance, which is then held by some one while the milking is going on, or is tied to the creature's leg by the hair of the tuft. Add to these the many threats and scolds uttered by the milker, and a faint idea of how a young heifer is broken in into milking may be conceived. Some cows are naturally unaccommodating and provoking; but, nevertheless, nothing but gentleness towards them will ever render them less so. Some cows are only troublesome to milk for a few times after calving, and soon become quiet; others kick pertinaciously at the first milking. In the last case, the surest plan is for the milker, while standing on his or her feet, to place the head against the flank of the cow, stretch the hands forward, get hold of the teats the best way possible, and let the milk fall to the ground. In this position it is out of the power of the cow to hurt the milker. Such ebullitions of feeling, at the first milking after calving, arise either from feeling pain in a tender state of the teat—most probably from inflammation in the lining membrane of the receptacle; or simply from titillation of the skin of the udder and teat, which becomes the more sensitive as the heat increases; or the udder, being still hard, gives pain when first touched. Should

the udder be difficult to soften, the advice of Youatt may be tried, by allowing the calf to suck at least three times a-day until the udder becomes soft.

This will doubtless cure the udder, but may cause another species of restlessness in the cow when the calf is taken from her. Still, rather let the milker suffer inconvenience than the udder of the cow be injured. Be the cause of irritation what it may, one thing is certain, that gentle and persevering discipline will overcome the most turbulent temper in a cow. Milking affords different degrees of pleasure to different cows. One yields its milk with a copious flow, with the gentlest handling; another requires great exertion to draw the milk in streams no larger than threads. The udder of the gentle one has a soft skin, and short teats like velvet; that of the hardened one, a thick skin, and the teats long and tough like tanned leather.

Artificial Means of Milking.—A plan of drawing milk from the cow was recommended by Mr Blurton, Field Hall, Staffordshire, by introducing tubes into two teats, and milking the other teats at the same time. He was once of opinion that a tube in each teat would draw away all the available milk from the udder; but, finding his mistake in this, he adopted the following method of milking. The tubes are called *siphons*, though they have none of the properties of the true siphons. His improved plan of milking is this: "The milker sits down as in the common method, fixing the siphon can (pail) firmly between his knees: he then takes hold of the near-hand teat with a slight pressure of his right hand, and with his left introduces the *small* tube of the siphon an inch or more into the teat, putting the thumb on the large tube, to prevent the milk from running out till completely introduced—and so on with the near fore-teat, reserving the two furthest teats to be milked by hand. By this method three teats can be milked with the right hand, assisted by the siphons, in the time one can be milked with the left, and this with ease and comfort. It may be here observed that the action of milking one or two teats by hand, is quite sufficient to induce the cow to give her milk down freely from those milked by the siphons; as the cow does not possess the power of retaining her milk in any one quarter of the udder while it flows freely from the others."

These tubes, containing a small and larger end, beyond which they cannot pass into the teat, may be made of ivory, bone, or metal. They should be thrown into the pail and milked on before being used, and when taken out of the teat, let fall into the can. On being used they should be dipped in boiling water and blown through. They do not seem to possess any advantage over the hand; on the contrary, the hand must be employed to complete what they cannot accomplish, in drawing off the last drop of milk, and must be in use when they are employed.

Milking-tubes.—Milking-tubes have been invented by Cooper & Co., Sheffield. They consist of 4 india-rubber smooth tubes about the thickness of a goose-quill, 6 inches in length, as in fig. 244. To one end of them is attached an electro-plated tube, 2 inches in length, closed at the upper end, and perforated there with 3 opposite holes in each side, and at the other end is inserted a short open similar metal tube of about ¾ inch in length; the 4 tubes being held together with an indiarubber band. In using these tubes they are thrown into the milking-pail, and a small quantity of milk is milked upon them by the hand from each teat. Each tube is then inserted into the hole of the teat with the right hand, while drawing down the teat with the left hand, until the milk flows freely through it. The pail is placed on the ground under the combined orifices of the tubes, and remains there until the milk ceases to flow, when the tubes are removed.

Fig. 244.—*Milking-tubes.*

About 1862 an apparatus for milking cows was presented to public notice, in which the *air-pump* was used to extract the air out of tubes which were connected by finger-pieces to the teats of the cows, and the pressure of the atmosphere on the udder expelled

the milk out of it. It was not easy to fit the finger-pieces air-tight upon the teats; a restive cow could easily throw the whole apparatus out of gear; and the apparatus did not milk clean. This invention made a sort of sensation at the time, which soon subsided.

In 1864 Barland's "pocket self-milking apparatus" was brought out. It simply consists of the insertion of a tube, with a flange upon it, into each teat, and the milk flows through it from the udder.

Mr Blurton very properly advocates clean milking, and describes a good plan of drawing away all the milk from an udder. No implement can draw away the milk clean from the udder; the hand alone can do that. "In aftering," he says, "I have adopted the plan of using the *left hand to press down the thick milk* into the receptacle and teat, at the same time *milking with the right hand;* then, in a similar manner, discharging the whole from the remaining quarters of the udder." He adds what is very true, that "it must not be snpposed that this method is distressing to the animal; on the contrary, her quietness during the process is a satisfactory indication that it occasions no pain, but rather an agreeable sensation." [1]

Sore Udder.—The udder, in cases of heifers, becomes not only uneasy before calving, but is subject to inflammation afterwards. "The new or increased function which is now set up," says Youatt, "and the sudden distension of the bag with milk, produce tenderness and irritability of the udder, and particularly of the teats. This in some cases shows itself in the form of excoriations or sores, or small cracks or chaps on the teats; and very troublesome they are. The discharge, likewise, from these cracks, mingles with the milk. The cow suffers much pain in the act of milking, and is often unmanageable. Many a cow has been ruined, both as a quiet and a plentiful milker, by bad management when her teats have been sore. . . . She will also form a habit of retaining her milk, which very speedily and very materially reduces its quantity. The teats should be fomented with warm water in order to clean them, and get rid of a portion of the hardened scabbiness about them, the continuance of which is the greatest pain in the act of milking; and, after the milking, the teats should be dressed with the following ointment: Take 1 oz. of yellow wax and 3 oz. of lard, and melt them together, and when they begin to get cool, rub well in ¼ oz. of sugar-of-lead and 1 drachm of alum finely powdered." [2]

Milking Period.—Cows differ much in the time they continue to milk, some not continuing to yield it more than 9 months, others for years. The usual time for cows that bear calves to give milk is 10 months. Many remarkable instances of cows giving milk for a long time are on record. "The immense length of time for which some cows will continue to give milk," says a veterinary writer, "if favourably treated, is truly astonishing; so much so as to appear absolutely incredible. My own observation on this subject extends to four most remarkable cases: 1. A cow purchased by Mr Ball, who resided near Hampstead, that continued to give milk for 7 years subsequently to having her first and only calf. 2. A large dun Suffolk cow, shown to me as a curiosity by a Yorkshire farmer. This animal, when I saw her, had been giving milk for the preceding 5 years, during which period she had not any calf. The 5 years' milking was the result of her second calving. During that period attempts had been made to breed from her, but ineffectually. 3. A small aged cow, belonging to a *fermier* near Paris, that gave milk for 3 years subsequent to her last calf. 4. A cow in the possession of Mr Nichols, postmaster, Lower Merrion Street, Dublin. This animal was in Mr Nichols's possession 4 years, during the entire of which time she continued to give an uninterrupted supply of milk, which did not diminish in quantity more than 3 pints *per diem*, and that only in the winter months. . . . He disposed of her for butchers' meat, she being in excellent condition. The morning of the day on which she was killed, she gave her usual quantity of milk."

Spaying Cows.—The same writer proves fully the possibility of securing permanency of milk in the cow. This is

[1] Blurton's *Pract. Ess. Milk.*, 10-12.

[2] Youatt's *Cattle*, 552.

effected by simply *spaying* the cow at a proper time after calving. The operation consists in cutting into the flank of the cow, and, by the introduction of the hand, destroying the ovaries of the womb. The cow must have acquired her full stature, so that it may be performed at any age after 4 years. She should be at the flush of her milk, as the future quantity yielded depends on that which is afforded by her at the time of the operation. The operation may be performed in ten days after calving, but the most proper time appears to be 3 or 4 weeks after. The cow should be in high health, otherwise the operation may kill her or dry up the milk. The only preparation required for safety in the operation is, that the cow should fast 12 or 14 hours, and the milk be taken away immediately before the operation. The wound heals in a fortnight or three weeks. For two or three days after the operation the milk may diminish in quantity; but it regains its measure in about a week, and continues at that mark for the remainder of the animal's life, or as long as the age of the animal permits the secretion of the fluid; unless, from some accidental circumstance—such as attack of a severe disease—it is stopped. But even then the animal may easily be fattened.

Advantages of Spaying.—The advantages of spaying are: "1. Rendering permanent the secretion of milk, and having a much greater quantity within the given time of every year. 2. The quality of the milk being improved. 3. The uncertainty of, and the dangers incidental to, breeding, being to a great extent avoided. 4. The increased disposition to fatten, even when giving milk, or when, from excess of age, or from accidental circumstances, the secretion of milk is checked; also the very short time required for the attainment of marketable condition. 5. The meat of spayed cattle being of a quality superior to that of ordinary cattle."[1] With these advantages breeders of stock can have nothing to do; but since the operation is said to be quite safe in its results, it may attract the notice of cowfeeders in town.

Preventing Udders from Running.—From some cause, the tissues of the teat may lose the power of retaining the milk in it. To prevent the running out of the milk from the cow's udder, this expedient may be adopted with a chance of success: Place an india-rubber band round the teats of the cow, and, in case the band should insert itself too deeply into the teat to be easily removed at milking, wrap the teat round with a piece of linen or thin soft leather under the band, so that the under part of the linen may be easily taken hold of in removing the band.

[1] Ferguson's *Distem. among Cat.*, 29-36.

CALF-REARING.

Importance of Calf-rearing.—Calf-rearing, the root and the rise of the cattle-breeding industry, has not received from the general body of farmers such full and careful attention as it deserves, or as it is capable of repaying. It is undeniable that the live-stock resources of the United Kingdom might advantageously be developed to a much greater extent. The growing importance of live-stock interests in British agriculture is manifest to all. In this expansion calf-rearing must play a leading part. Breeding is of course the starting-point, and the rearing of the calf is the first great step in the progress of the industry.

Aversion of Farmers to Calf-rearing.—With many farmers calf-rearing finds little favour; often, we venture to say, for no better reason than that it is a troublesome business, demanding constant and careful attention. With skilful and careful management, calf-rearing, where circumstances are at all favourable, is almost invariably remunerative. This much, however, it must have, and it rarely succeeds where not well conducted. The young animals must be fed with skill and regularity, and their health and comfort carefully attended to in every way. When this responsible work is left entirely to hired servants, it may be imperfectly or irregularly performed, with the result that the calves make unsatisfactory progress, or perhaps become impaired in health. The farmer thus loses faith in the benefits of calf-rearing. He has, perhaps, at last learned that the cause of the mischief is improper treatment; but personal supervision, or super-

vision by some member of his family or employees in whom confidence could be placed, may be found irksome or inconvenient, and thus again the industry of calf-rearing loses in favour.

Calf-rearing on Large Farms.—This demand which calf-rearing makes upon the careful personal supervision of the farmer or some member of his family, is undeniably the main reason why upon many large farms well suited for breeding, so few calves are brought up. We lay a little of the blame for this at the door of modern social fashion. Upon a large farm the farmer himself has many other duties which draw him away from superintending the feeding and treatment of calves; and it is not the fashion for sons and daughters of large farmers to give their attention to such matters. This conception of social life upon the farm may easily be carried too far. It is not suggested that the sons and daughters of men of capital should be expected to put their hands to the manual work of calf-rearing. There is a difference between this, however, and the superintending of work done by hired servants. The daughters and sons of farmers will be none the less ladies and gentlemen if they should make themselves acquainted with certain details of their father's business, and assist him in seeing that these details are carried out with due care and regularity.

Deficiency of Store Cattle. — The growth in the breeding of cattle has not kept pace with the increase in the consumption of beef. The supply of home-bred store cattle has not been equal to the demands of the feeders. Farmers have been complaining of unsatisfactory financial results from fattening cattle, and the main difficulty has been the fact that, on account of deficient supply, store cattle have been dearer than fat animals —that feeders have had to pay more for the lean cattle than the price of beef would warrant.

Home-breeding, not Importation, the Remedy.—The proper remedy for this state of matters is the extension of home-breeding — assuredly not the importation of foreign lean cattle. Let that be resorted to only when our own resources in cattle-breeding have been developed to the fullest advantageous extent. We are far short of that limit yet; and we would fain hope that until it is reached the best efforts of our leaders of agriculture may be directed to the encouragement of home-breeding rather than to the devising or providing of means of increasing the embarrassments of home-breeders by importing foreign-bred lean stock.

Rear more Calves.—In any scheme for increasing the supply of home-bred store cattle, calf-rearing must play an important part. We must not only breed more calves, but we must also rear more. We should rear all we breed, or nearly so, and rear them well, too; for let it ever be kept in view that what an animal loses with bad treatment as a calf, it can hardly ever fully recover. But we do not mean by rearing well, any sort of extravagant treatment. In fact, we believe there is room for much greater economy in the rearing of calves. In connection with calf-rearing on dairy farms, or wherever milk can be turned to good account, this point is of special importance.

Breed longer from Cows. — We should breed longer from cows. A custom by no means uncommon is to buy a cow for a temporary supply of milk, and fatten her off when she gets dry. Now this is a serious loss. Breed from all suitable cows as long as practicable.

Breeding from Heifers.—From all heifers that are suitable, whether intended for cows or not, take one, two, or perhaps even a third calf. Keep them well all the while, letting the calves suckle; and if the heifer is not to be kept for a cow, she may be fattened off and sold as heifer-beef. The calf or two will have done her little or no harm in the butcher's eye, if only she does not show the udder of a cow. This will not often arise when the calves suckle. This question we lately put to an extensive salesman in the north of England, who replied that his experience was that two calves or so in no way spoiled the sale of the young heifer, if only there were no display of udder, and if she were plump, level, and well fattened. He added that a lot of young heifers never came before him for sale but he regretted that so much valuable material was being wasted. Premature fatting of heifers

is really killing the goose that lays the golden egg. In these times farmers cannot afford such waste as that.

Are Calves Nuisances?—Unfortunately not a few dairy farmers look upon calves as little else than nuisances—as necessary evils — something which they would never wish to have if only they could without them get cows in milk. This is a great misfortune, and shows clearly that while the cry is for more store stock, there must be something radically wrong somewhere. The fact is, calf-rearing is very imperfectly understood.

We are convinced that dairy farmers, as well as other farmers in all parts suited for breeding, would find, in well-conducted calf-rearing, returns which would amply repay careful treatment and judicious and liberal feeding. The dairy farmer may dislike the calf because he has found it a greedy and bad-paying customer for its mother's milk. But if he has done so, he has had himself to blame. A good calf will well repay a moderate allowance of its mother's milk for a short time; and we would emphasise this point, that it is only for a very short time at the outset that there is any necessity to give milk—at any rate, new milk —to calves.

Milk Substitutes.—Scientific research and commercial enterprise have placed us in possession of many advantages unknown to our forefathers. In the simple matter of calf-rearing we have gained much in this way. Why, the market is teeming with cheap milk substitutes; and, without going the length of affirming that these foods are worthy of all their energetic vendors say of them, yet we unhesitatingly say that, with substantial advantage to themselves and the general public, farmers might draw upon them much more largely than they have done heretofore. Undoubtedly the use of these prepared foods is on the increase; and we think that, by a judicious use of them and other simple natural foods, calf-rearing might be increased to a very great extent, both on dairy and mixed husbandry farms.

Rearing or Selling Calves.—We do not say that all farmers should rear their calves. It may suit some better to sell the calves when one, two, or three weeks old. If the calves are of a good class they will sell readily at handsome prices. While it may suit some to breed calves and sell them young, it will undoubtedly pay others to adapt their arrangements specially for rearing. Instead of keeping large stocks of cows, they may buy in young calves, and rear them partly on milk and other suitable food. In certain cases these bought-in stock may be carried on and fattened when from two to three years old. In others they may be simply reared, and sold as lean stock when from ten to eighteen months old.

Details of Calf-rearing.

There is, of course, much variety in the systems of calf-rearing pursued throughout the country. And in this as in most other farming matters, it would be unwise to lay down hard-and-fast rules as the best for all circumstances. Various approved methods will be described, and with these in view the intelligent farmer will arrange his practice to suit his own peculiar conditions and objects.

Housing Calves.—The comfortable and economical housing of calves is a matter that demands careful attention. Calves are either suckled by their mothers, or brought up by the hand on milk and other substances. When they are suckled, if the byre be roomy enough —that is, 18 feet in width—stalls may be erected for them against the wall behind the cows, in which they are tied up; or, what is a less restrictive plan, they may be put together in large loose boxes at the ends of the byre, or in adjoining apartment, and let out at stated times to be suckled.

When brought up by the hand, they are put into a suitable apartment, preferably each in a crib to itself, where the milk is given to them. The advantage of having calves separate is, that it prevents them, after having had their allowance of milk, sucking one another, by the ears, teats, scrotum, or navel, by which malpractice ugly blemishes are at times produced. When a number of calves are kept together, they should all be muzzled to prevent this sucking.

Calf-crib.—The crib for each calf should be 4 feet square and 4 feet in height, sparred with slips of tile-lath,

and have a small wooden wicket to afford access to the calf. The floor of the cribs, and the passages between them, should be paved with stone, or laid with asphalt or concrete. Abundance of light should be admitted, either by windows in the walls, or skylights in the roof; and fresh air is essential to the health of calves, so that ventilation should be carefully attended to. So also should the cleaning of the calf-cribs. The cribs should be regularly cleaned out; and it is a good plan to sprinkle the floors daily with some disinfectant, such as diluted carbolic acid—one part of acid to twenty of water. This will keep the atmosphere pure and wholesome, which is very desirable for the young animals.

If the calf compartment be separate from the cow-house, it should communicate with the latter by a close door, having upper and lower divisions, into a court with a shed, which the calves may occupy till turned out to grass.

The crib should be fitted up with a manger to contain cut turnips or carrots, and a high rack for hay, the top of which should be as much elevated above the litter as to preclude the possibility of the calf getting its feet over it.

The general fault in the construction of calves' houses is the want of light and air — both great essentials; light being cheerful to animals in confinement, and air essential to the good health of calves. When desired, both may be excluded. The walls of the calves' house should be plastered, to be neat and clean, and should be whitewashed at least once every year.

In some cases the cribs are so constructed that the calf has access, either at will or when the door of the crib is opened, to a larger enclosure in which the young animal can exercise its limbs.

The front and wicket of a calf's crib which we have seen in use, is shown in fig. 245, in which a wicket-door gives access to the crib. The hinge is of wood, simple and economical. It consists of the rails of the wicket being elongated and rounded off, and their lower face end shaped into a round pin, which fills and rotates in a round hole in a billet of wood securely screwed to the upright door-post of the crib. Another billet is screwed on immediately above the hinge, to prevent the door being thrown off the hinges by any accident.

Cross-tailed iron hinges, of the lightness suited to such doors, would soon be broken.

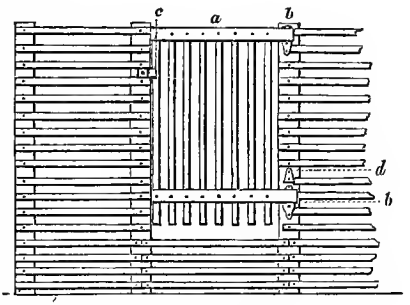


Fig. 245.—*Calf's-crib wicket.*

a Wicket to give access to the crib.
b b Its hinges of wood.
c Thumb-catch for fastening wicket.
d Billet to prevent wicket being thrown off.

More frequently the spars forming the crib are placed upright, and are of greater strength than indicated in the illustration.

Care in letting out Calves.—When the calves are fit to be put out in the open air, after it becomes mild, they should be put into a shed for some nights before being turned out to grass, and also for some nights when at grass. The shed should be fitted up with mangers for turnips, and racks for hay, and a trough of water.

Navel-string. — The state of the navel-string is the first thing that should be examined in a new-dropped calf, that no blood be dropping from it, and that it is not in too raw a state. The bleeding can be stayed by a ligature on the string, but not close to the belly. Inattention to the navel-string may overlook the cause of the navel-ill; and, insignificant as this complaint is usually regarded, it carries off more calves than most breeders are aware off.

Youatt remarks: "Possibly the spot at which the division of the cord took place may be more than usually sore. A pledget of tow, wetted with friar's-balsam, should be placed over it, confined with a bandage, and changed every morning and night; but the caustic applications that are so frequently resorted to should be avoided. Sometimes, when there has been previous bleeding, and

especially if the caustic has been used to arrest the hemorrhage, and at other times when all other things seemed to have been going on well, inflammation suddenly appears about the navel between the third and eighth or tenth day. There is a little swelling of the part, but with more redness and tenderness than such a degree of enlargement could indicate. Although there may be nothing in the first appearance of this to excite alarm, the navel-ill is a far more serious business than some imagine. Fomentation in the part, in order to disperse the tumour, the opening of it with a lancet if it evidently *points*, and the administration of 2 or 3 oz. doses of castor-oil, made into an emulsion by means of an egg, will constitute the first treatment; but if, when the inflammation abates, extreme weakness should come on, as is too often the case, gentian and laudanum, with perhaps a small quantity of port wine, should be administered."

Inflammation of the navel is often caused by one calf sucking another.

Calf's First Food.—The first food the calf receives is the biestings—the first milk taken from the cow after calving. Being of the consistence of the yolk of the egg, it seems an appropriate food for a young calf. By the time it gets its first feed, the calf may have risen to its feet. If not, let it remain lying, and let the dairymaid take a little biestings in a small dish—a vessel formed like a miniature milk-pail, fig. 242, and of similar materials, is a convenient one—and let her put her left arm round the neck of the calf, support its lower jaw with the palm of the hand, keeping its mouth a little elevated, and then open the mouth by introducing the thumb of the same hand into the side of it. Then let her fill the hollow of her right hand with biestings, and pour it into the calf's mouth, introducing a finger or two with it for the calf to suck, when it will swallow the liquid. Let it get handful after handful, as much as it is inclined to take. When it refuses to take more, its mouth should be cleaned of the biesting that may have run over. Sometimes, when a calf is begun to be fed lying, it attempts to get upon its feet; and, if able, let it do so, and rather assist than prevent it.

Some are afraid to give a calf as much biestings at first as it can take, because it is said to produce the navel-ill. Let it take as much as it pleases. As to the navel-ill, it proceeds from neglect of the proper inspection and precaution after the calf is born.

Teaching Calves to Drink.—The process of feeding a new-dropped calf by hand is here minutely described, because absurd modes are practised in doing it. It is common to plunge the calf's mouth into the entire quantity of biestings, and because the liquid bubbles around its mouth with the breath from the nose, and it will not drink, its head is the more forcibly kept down into the vessel. How can it drink with its nose immersed amongst the liquid? and why should a calf be expected at first *to drink with its head down*, when its natural instinct would lead it to *suck with its head up?*

It should be borne in mind that feeding calves by the hand is an *unnatural* process; nevertheless it is convenient, practicable, and easy, provided it is done in a careful manner. The young calf must be *taught to drink*, and a good mode of teaching it is the one here given. In this way it is fed as often as the cow is milked, three times a-day.

Another Method of Teaching to Drink.—After the first two or three days, another plan should be adopted, for the calf should not be *accustomed* to suck the fingers, and it may refuse to drink without their assistance. The plan is to put a finger or two of the right hand into its mouth, and holding the pail of milk with the left under its head, bring the mouth gradually down into the pail, with the nostrils free, where the fingers induce it to take a few gluts of the milk; and while it is doing this, the fingers should be withdrawn, while the mouth is gently held down in the milk, when it will drink a little of itself. In a few days more the fingers will not be required, the head only being put down to the milk, and in a few more still, the calf will *drink* of its own accord.

Reform in Calf-feeding.—In the method of feeding calves during the first few months of their existence, there has been almost as great a revolution as

in any other branch of farm practice. The old notion that at least three months of feeding upon whole milk as it comes from the cow was necessary for successful calf-rearing, has been exploded. In many cases, almost entirely in herds of pure-bred cattle, the calves still suckle their dams. But beyond these herds comparatively little new milk is now employed in rearing calves, reliance being more largely placed upon skim-milk and milk substitutes. Excellent results are obtained by the new method, and the fresh milk and cream thus saved from the calves are advantageously used for other purposes, sold to milk retailers, or made into butter and cheese.

Composition of Biestings. — The biestings or first milk after calving differs considerably in composition from ordinary milk. It contains an exceptionally large proportion of casein or cheesy matter, as the following analysis of ordinary milk and biestings will show :—

	Ordinary Milk.	Biestings.
Casein (cheese)	4.48	15.1
Butter	3.13	2.6
Milk-sugar	4.77	...
Saline matter	0.60	...
Mucus	...	2.0
Water	87.02	80.3
	100.00	100.00

The prevailing methods of feeding calves may be briefly described as follows :—

Suckling.—This is "nature's method." It is the surest and simplest means of attaining the highest development in the calf. When maximum growth in frame, flesh, and fat is the main object, and "cost of production" of little moment, suckling is the most reliable system. It is therefore pursued largely in herds of pure-bred cattle, especially by breeders who enter the showyard lists. The usual plan is to allow the calf to run with its dam, and to suck the cow at pleasure, or allow it access to her at regular intervals. The former is preferable, and will make the best calf. If the dam has not sufficient milk to raise the calf, or if her milk is desired for other purposes, the calf may be put to a nurse-cow, which the youngster will suck as readily as it would suck its own mother. A nurse-cow is sometimes averse to a strange calf, but with a little care at the outset she will gradually lose this, and will fondly welcome its attentions when her udder is in want of relief.

Suckling two or more Calves.—An average milker will yield more milk than one calf requires. A second calf may therefore be admitted, and a good, well-fed cow will easily raise two strong calves. In many cases, indeed, one cow rears two sets of calves, sometimes four in a-year, but more frequently three. After the first two calves have been weaned, a good cow should have enough milk remaining to rear at least a third calf, and if she had calved early in the season, be naturally a heavy and enduring milker, she may, with liberal feeding, be quite able to rear a second couple of youngsters. A cow that is capable of doing this will give a good account of her year's feeding.

Suckling and Milking combined.—When these additional calves cannot be advantageously obtained, or when fresh milk is desired for some other purpose than calf-rearing, the cow may be left with the one calf and her surplus milk drawn from her once, twice, or thrice a-day, according to her supply and the requirements of the calf. This method has other advantages apart from the supply of milk it provides for household or other purposes. It accustoms the cow to milking as well as to sucking, and by the operation of milking, systematically and efficiently performed, the capacity of her milk-vessels is developed, and her flow of milk stimulated; while the risk of the calf gorging itself with too much milk at any one time is obviated. Of course this supplementary process of milking the nurse-cow may be carried too far. The calf must not be robbed of its due amount of food. One objection to *partial* suckling is, that a cow suckling a calf does not allow milking afterwards with the hand in a kindly manner. Unless, therefore, cows are kept for the purpose of suckling throughout the season, they often become troublesome to milk with the hand after the calves are weaned.

Decrease in Suckling.—Suckling is not pursued nearly so extensively as formerly. Increased facilities for utilising

surplus milk and cream, and the better understanding of calf-rearing by other means, have tended to curtail the practice of suckling calves. Even in pure-bred herds it has lost ground. It is a comparatively costly system, and is therefore not to be commended in ordinary farm practice. Suckling saves the trouble of milking the cows and giving the milk to the calves; but a saving of trouble may be a loss of money in the rearing of calves. An objection to suckling exists when one cow brings up two calves at a time, that the quantity of milk received by each calf is unknown, and the faster sucker will take the larger share. True, they are both brought up; but are they brought up as well as when the quantity of milk consumed is known to be sufficient for the support of each? The milk becomes scarcer, too, as the calves get older, instead of becoming more plentiful, as should be the case to satisfy the growing wants of the young animal.

Suckling with Heifers.—Reference has already been made to the plan of taking at least one crop of calves from heifers that are not intended to be added to the regular stock of cows. This is a species of "catch crop" which may often be taken with advantage. It is the usual practice to allow these calves to suck their youthful mothers. This does not—as milking would—develop the udder so as to spoil the sale of the young cow in the fat-stock market, and by liberal feeding she may be fattened while she is rearing her calf.

Hand-rearing.—Although this is an artificial, it is nevertheless the most general, as well as the most economical, system of rearing calves. It enables the farmer to use for his calves as much or as little as is thought desirable of his supply of milk, and it permits him also to avail himself of those cheaper milk substitutes which are now within his reach. He has thus, in the hand-rearing methods, much freer choice and greater scope for economical and skilful management than in the simple system of suckling.

It may be admitted that no perfect substitute for milk has as yet been discovered or devised. It by no means follows, however, that milk is the cheapest or most economical, as well as the most perfect, food for calves. The increased and still increasing demand for milk and its products for household purposes has withdrawn vast quantities of milk formerly employed in calf-rearing. This diversion is still going on, and it is to the farmer's advantage that it should be stimulated, for it practically adds another string to his bow. If he can advantageously sell or utilise his milk otherwise, he should use as little as possible of it in rearing calves. For these youngsters he has the choice of an ample assortment of other foods, the economical worth and efficiency of which have been well established. In the selection, mixing, preparation, and feeding of these foods lies the art of modern calf-rearing. It is an important item in the routine of the stock-owner's duties, and demands studious and careful attention.

Prevalent Methods.—Perhaps the most widely prevalent method of rearing calves is to feed them entirely on new milk for a short period at the outset—that period varying from two to six weeks,—and afterwards partly on new milk, skim-milk, and artificial food; or upon skim-milk and artificial food, without any of the rich milk as it comes from the cow. It is, no doubt, a good plan to let the calf have all the new milk it can readily consume for at least two or three weeks at the outset. By degrees skim-milk may be substituted for new milk, and when the new milk is wholly, or almost wholly, withdrawn, the skim-milk must be supplemented by some other richer food.

Skim-milk for Calves.—Skim-milk alone is not a well-balanced food for calves. The butter-fat has been almost wholly removed from it, and what remains is not sufficiently provided with all the elements necessary for the healthy development of the young animal. Skim-milk, left by an efficient system of creaming, will, on an average, contain the following per 100 lb.:—

Casein	3.5 lb.
Albumen	.7 "
Fat	.5 "
Sugar	4.0 "
Ash	.8 "
	9.5 lb.

The skim-milk thus retains almost all the casein and sugar in the new milk; but so effective are some of the modern processes of separating the cream from the milk, that only the merest traces of butter-fat may remain in the skim-milk. About one-sixth of the casein and albumen consists of nitrogen, and as far as it goes, skim-milk is undoubtedly a valuable food, and may be used with great advantage in conjunction with other feeding material.

Skim-milk should not be fed largely by itself to calves, for calves so fed are liable to scour, indigestion, and other bowel-complaints. It is a dangerous practice to abruptly substitute skim-milk for new milk as the main food of calves. The withdrawal of the new milk should take place gradually, and other substances should be introduced in corresponding ratio to make up for the deficiencies of the skim-milk.

Professor Stewart on Skim-milk.—"Skim-milk is much more valuable as a food than is generally supposed. It contains all the qualities of the milk except the cream. The casein, the most valuable food-constituent of the milk, and the milk-sugar, or whey, are still in it. If you feed only skim-milk to a healthy calf, it will require on an average from 15 to 20 lb. of milk to make 1 lb. of live-weight during the first ninety days, if the calf is given all it wants; and a good eater will gain 2½ lb. per day." Professor Stewart has a high opinion of boiled linseed as food for calves. He points out particularly that, given along with skim-milk, the oil of the linseed "will make good the loss of the cream in the milk."[1]

Scalding Skim-milk.—It is well to have the skim-milk scalded as soon as the cream has been taken from it, because it will thus longer remain sweet. A simple way of scalding is to insert a vessel full of the skim-milk into a larger vessel containing hot water. Some even boil the skim-milk, and are thus able to keep it sweet a whole week.

We know of one large farmer who sells his milk on the six week-days, keeps at home his Sunday's milk, has it boiled on Monday, and gives a portion of it to his calves every day. The supply of this milk often lasts the whole week. If the Sunday's milk falls short, the calves get two quarts of new milk, with one quart of water added.

Artificial Food for Calves.—The other substances most largely used either in supplement of or as substitutes for milk in rearing calves, are linseed, linseed-cake, oatmeal, Indian-corn meal, palm-nut meal, malt, pea-meal, barley-meal, or some specially prepared food. The characteristics and composition of these articles are described in the chapter on "Foods," which should be referred to and consulted carefully in arranging the dietary of animals.

Preparing Foods for Calves.—All these articles of food are given to calves in the form of gruel, and they can hardly be too well steeped or boiled. It is desirable to have the linseed and linseed-cake ground into meal before boiling. Gruel from linseed-cake is often prepared by adding four parts of boiling water to one part of the meal derived by grinding the cake, and allowing the mass to remain covered up for twelve hours. Palm-nut meal may be prepared in a similar manner. In making linseed-gruel, water should be added so as to give almost a gallon and a half of gruel for every pound of linseed. If the gruel is found to purge the calf, add a little more water, and for a day or two give rather less of the gruel and more of the skim-milk. A little wheat-flour, mixed with gruel, is also a useful and simple remedy in cases of purging. Mixtures of these meals are often made into gruel for calves, and the selection of the particular articles to be used will be regulated mainly by their market prices at the time.

Quantities of Milk for Calves.—In the majority of cases where calves are raised by hand-feeding, they get about two quarts of new milk twice or three times a-day—four to five or six quarts in all—during the first two, three, four, or six weeks of their existence. At these various periods, according to custom or to the supply of new milk and the other demands for it at the time, a beginning is made with the substitution of skim-milk for new milk. A very small proportion of the latter is given at first, by degrees it is increased, and soon the new

[1] *Feeding Animals*, 235-237.

milk is wholly withdrawn. Some indeed give new milk only for about two weeks, and others continue it for six weeks or two months, perhaps even longer. The new milk and skim-milk are given together. Some feed calves three times a-day in the first few weeks, and others only twice.

Allowances of other Foods.—Supplementary foods should be begun soon, as soon perhaps as the curtailing of the new milk has commenced. The artificial food, made into gruel, is given along with the milk, and at the outset the gruel should be given in very small quantities. Sudden changes of food may inflict serious injury upon the health of the tender young animal. Some begin to give gruel to calves before they are a month old, others delay till the animal is in its sixth or seventh week. The daily allowance of gruel will of course vary with the age of the calf, and the quantity of milk it is receiving. No fixed "bill of fare" can be prescribed with safety. The appetite of the young animals must be watched closely, and special care taken to keep the bowels in good order. Feed calves liberally, but never overdo them. Let them have just as much as they can readily consume at the time; keeping on the scrimp rather than the abundant side.

Perhaps the best guide to the young farmer will be a description of methods which have been pursued with success by various breeders.

Mr W. T. Carrington's System.—The late Mr T. Carrington, Uttoxeter, Staffordshire, who kept a dairy herd of over 100 cows, reared about 40 of his earliest heifer calves as follows: "They are not allowed to suck their dams; they have from four to eight quarts of new milk *per diem*, according to age, for three or four weeks. They are then fed with skim-milk, thickened with boiled linseed or oatmeal, and are taught as soon as possible to eat hay and a small quantity of linseed-cake. They are allowed to run on a grass field in May and June, and are after then generally left out altogether, with a shed to run into in very wet weather, or to avoid the heat of the sun and the teasing of the flies. The milk-feeding is altogether discontinued when they are about four months old. They are supplied with 1 lb. each per day of linseed-cake all through the year."[1]

A Common Plan with whole Milk.—Mr Wilson, late of Edington Mains, Berwickshire, describes the following system of feeding, which is common where whole milk and no skim-milk is used: Whole milk, warm from the cow, is given three times a-day for the first fortnight, and the calf is allowed to have as much of it as it will take. It may then be tempted to suck (and at length to eat) small bits of oilcake and sweet hay, and the mid-day meal of milk may be gradually reduced and ultimately discontinued; and when the calf at length takes slices of turnips and mangels freely, the milk may be brought down to five or six quarts per day, water being added to make up the necessary quantity. At seven or eight weeks the milk may be gradually reduced, and soon altogether discontinued.

A Gloucestershire Practice.—Mr Ruck, Cirencester, has reared his calves successfully upon the following food, with whole milk for the first few days, and then a little skim-milk: 7 lb. of finely ground linseed-cake dissolved in 2 gallons of hot water, to which is added 2 gallons of hay-tea, made by pouring hot water on good hay in a tub; and to this again is added 7 lb. of mixed meal, of wheat, barley, oats, and beans, in equal parts, steeped in 2 gallons of hot water. Of this mixture the calves get 2 quarts in the morning, further diluted with two quarts of warm water; and 2 quarts at night, also diluted with 2 quarts of warm water. Upon this gruel the calves thrive well, and are weaned when about 12 weeks old.

Mr Bowick's Plan.—In his useful paper on "Calf-rearing," Mr Thomas Bowick gives this account of his mode of *rearing* calves: "We manage to turn out from 25 to 30 calves annually—such as will pass muster anywhere—and never use at any time more than 6 gallons of new milk daily. For this purpose, as well as to obtain a regular supply of milk for other purposes, the calves are allowed to come at different periods extending from October to May.

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xiv. 401.

. . . We begin with new milk from the pail, which is continued for a fortnight after leaving the cow. Then skim-milk, boiled and allowed to cool to the natural warmth, is substituted to the extent of one-third the allowance. In another week the new milk is reduced to half, and at the same time, *not before*, boiled linseed is added to the mess: 5 lb. of linseed will make about 7 gallons of gruel, and suffice for 5 good-sized calves. As soon as they take freely to this food, the new milk may be replaced with that from the dairy, and the calf is encouraged to indulge in a few sliced carrots, green hay, or linseed-meal, or finely crushed oilcake. Amongst the multitudes of substitutes for milk that have at different times been recommended, we have found nothing better than those previously referred to; or linseed, 2 parts, and wheat 1 part, ground to meal, and boiled to gruel of moderate thickness, and then mixed with an equal quantity of skimmed milk. It is true we have omitted any allusion to 'Irish moss,' which calves seem to relish well, though it does not prove of a fattening nature. For the lot of calves named (25 to 30), 2 cwt. of this article is found a desirable addition, and lasts throughout the season." [1]

General Rules.—Major M'Clintoch writes thus: "It is very difficult to lay down an exact rule for feeding calves, as far as quantity is concerned; nor can a time be fixed for weaning, the appearance of forwardness in the animals being the best rule to go by. However, as a general mode, supposing a calf to be dropped in March, I would suggest that pure 'mother milk' should be given for a fortnight, then by degrees an admixture of oilcake gruel (1 quart of cake, ground fine, to 4 quarts of boiling water) introduced, and a sufficient drink allowed at each meal, so as to remove all hollowness from the flank. In a few weeks 6 gallons will be taken by the calf, and when the weather is favourable it should be allowed to run in some well-sheltered place where the pasture is sweet. In 3 months calves have an appetite for grass, and it is then that the process of weaning should begin." [2]

Spare Dietary for Calves.—The late Mr J. Chalmers Morton described the system of feeding in a case in which "5 cows reared 50 calves, their milk having been also to some extent skimmed for butter for the household. The cows were brought to the pail one after another from February until May; and the calves, brought as they could be got, received each a share of the partly skimmed milk, more and better milk being given to the very youngest, until they began to nibble shred swedes and hay. The sole addition to this food was oatmeal gruel; half a pint of finely ground best oatmeal for each calf being put morning and evening into about 2 quarts of scalding water, which was cool enough and cooked enough, by staying there all day or night, for use at the evening or morning meal respectively, after having thus stood 12 hours. This, with care always to give food which is perfectly sweet and not too cold, with attention also to the warmth and dryness of the accommodation that is given to the calf, has reared them in health, without a single loss, during the season." [3]

Liberal Treatment desirable.—Remarking upon the scrimp character of this dietary, Mr Morton adds: "It is more and more coming to be generally acknowledged, that for the production of the best and most profitable animals, whether for the dairy or the feeding-stall, the more liberal management of the calf is in the end the better way. To stint the young beast is to diminish its quality as a good doer from the very beginning. Whether for beef or for milk, it is well that good calf-flesh should be established at the outset, and that by no stinginess or severity of after-treatment should it be lost." [4]

Mr E. Bowly's System.—In his prize essay "On the Management of Breeding Cattle," the late Mr Edward Bowly, a noted English breeder of shorthorns, thus describes his system of rearing calves: "My early calves—those which drop from December till the end of February—I allow to suck the cows for a fortnight, then take them off, and give them as much as they will drink of skim-milk and thick gruel made from boiled

[1] *Jour. Royal Agric. Soc. Eng.*, xxii. 140, 152.
[2] *Ibid.*
[3] *Ibid.*, sec. ser., xiv. 403.
[4] *Ibid.*

linseed, in equal proportions, twice a-day. As soon as they are inclined to eat, I supply them with oilcake, carrots, and hay. When three months old I reduce the milk and linseed to once a-day, and in three weeks afterwards discontinue it altogether, continuing the food till they are turned out to grass. Then I give them 2 lb. of oilcake daily, which I continue, in addition to other food, for twelve months—that is, till they go to grass the following year."

Late Calves.—Mr Bowly states that those calves which drop late in March and during the summer months he allows to run with cows, after purchasing nurses for the purpose. He considered it desirable to remove the calves from their own dams, as those cows which are being sucked by calves will not always take the bull so soon as those milked by the hand.

Devonshire Custom.—A custom long prevalent, although not universal, in Devon, was to allow the calf to suck its dam for the first eight or ten days, then take it away and give it five pints of new milk per day for the first week, after which the new milk is gradually withdrawn, and skim-milk added, until, at the end of three or four weeks, the skim-milk is entirely substituted for the new milk, and then a little other food is by degrees introduced, such as turnips, cut into finger-pieces, as for sheep, and oat-meal or other gruel. In this way the youngsters are carried on till the grazing season begins.

Daily Allowance.—The quantities of food given to calves at each meal vary according to the size, breed, and condition of the animals. For a healthy calf of any of the larger breeds the following quantities are generally allowed: in the first week, 3 pints (new milk) at once, three times a-day, making 4½ quarts per day; gradually increased till, in the fourth week, the quantity is 5 pints at once, and three meals, making up 7½ quarts per day. At one month old, when the calves eat hay, finely sliced roots and cake, two meals a-day may suffice; the quantity at two months old being 4 quarts at a meal, or 2 gallons daily.[1]

A Perthshire Example.—On a well-conducted farm in Perthshire the following system is pursued: "For the first fortnight we give nothing save new milk; the third week the quantity of new milk is lessened, and skim-milk supplies the deficiency, a little linseed and oatmeal porridge being added to it. The oatmeal is well boiled, the linseed (cake ground down very fine) steeped in boiling water an hour or two previous to use. As to the quantity that should be given, experience will prove the best guide; a supply sufficient for one animal is frequently too much or too little for its neighbour. The great 'secret of success' in calf-rearing lies in being careful not to overload the stomach; the appetite should never be quite satiated. When eight or nine weeks old, a little clover-hay and finely cut swedish turnips are given, along with a small allowance of dry linseed-cake. Some difficulty is occasionally experienced in getting them to take to the latter substance; but by putting a small bit into the youngster's mouth just after it has finished its gruel or porridge, at which time it will suck greedily at anything within its reach, it soon acquires a taste for it. The allowance of porridge should be continued until the animals are five or six months old, after which it may be gradually discontinued. We have tried various of the calf meals, or milk substitutes, in the market, but found none fit to beat the oatmeal and linseed, either as regards moderation of first cost or the satisfactory after-results." [2]

A Useful Dietary.—Mr G. H. C. Wright gives the following as a useful table of rations for a calf:—

1st week—4 quarts of new milk at three meals.
2d week—4 quarts of new milk and 2 quarts boiled skim-milk at three meals.
3d week—2 quarts of new milk and 4 quarts boiled skim-milk at two meals, and ½ lb. boiled linseed.
4th week—6 quarts boiled skim-milk and ⅔ lb. boiled linseed at two meals.
5th week—6 quarts boiled skim-milk and 1 lb. boiled linseed at two meals.

1 lb. of crushed linseed (flax-seeds, not cake) will make rather more than 1 gallon of gruel.[3]

American Example.—Professor E.

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xiv. 495.

[2] *Farming World*, 1889, 23. [3] *Ibid.*, 1889.

W. Stewart says: "We have often had calves seventy days old fed with ½ lb. flax-seed and 1½ lb. of oatmeal each, with 20 lb. of skim-milk per day, that have gained in weight 30 to 37 lb. in ten days—an average of over 3¼ lb. each per day. The flax-seed and oatmeal are boiled, and then mixed with the milk. The average weight of these calves when dropped was about 60 lb.; their average weight at seventy days was 230 lb.;—they had consequently gained 2.42 lb. per day. They were fed on new milk for one week. then half-and-half skim-milk for another week, then upon skim-milk and 4 oz. of boiled flax-seed each per day; at thirty-four days old, flax-seed increased to ½ lb., and ½ lb. oatmeal added; the latter was increased to 1 lb. in a few weeks, and afterwards another ½ lb. added."[1]

Whey for Calves.—Whey—what remains of milk after the cream and casein or cheese are taken away—is much more useful as food than is generally supposed. Often this refuse of the dairy is thrown away as of little value; but some consideration will show that in this there is great waste. Whey consists of about 93 per cent of water and 7 per cent of solids—nearly the same proportions as in common turnips. The solid matter consists of about 70 per cent of the sugar of milk, 14 per cent albuminous compounds—containing about 3.75 per cent of nitrogen, 11 per cent of ash, and nearly 5 per cent of butter or pure fat. It is probable that at least one-half of the mineral matter or ash is made up of common salt, derived from the salt used in the cheese-making. The albuminous matter makes up very nearly 1 per cent of the whole of the whey, and this, with ⅓ per cent of butter-fat and 5 per cent of milk-sugar, proves whey to be an article of food worthy of careful utilisation.

Supplementing Whey.—But while the food constituents in whey are considerable, and may be turned to good purpose in feeding calves, these must be largely supplemented by other richer commodities in order to sufficiently nourish the young animal. For the successful and economical selection and proportioning of these supplementary foods great care and no little skill are necessary. Fat-forming matter must be added to make up for that removed in the cream; and nitrogenous matter, phosphate of lime, magnesia, sulphur, soda, &c., taken away in the casein, must likewise be replaced. These elements, added in due proportion to the easily digested milk-sugar in the whey, make a very wholesome food for calves. These supplements to whey would be well supplied by linseed and linseed-cake—say ½ lb. of each well boiled and added to 2 gallons of whey for a young calf. Some might prefer oatmeal, barley-meal, or wheat-bran.

Care in use of Whey.—In utilising whey as food for stock, certain precautions are necessary. It should be used while fresh and sweet, as, if allowed to become sour, it may seriously derange the system of the animal. Then whey should not be fed alone, on account of its being so unevenly balanced—too much water and too little dry matter. To enable the animal to obtain the necessary amount of dry matter, it would have thus to swallow too much water. Therefore, give the whey in conjunction with other drier and more concentrated food.

Hay-tea for Calves.—There is considerable feeding value in hay-tea. In fact, well-made hay-tea is almost a perfect food as far as it goes. Professor E. T. Stewart says: "The soluble nutritive constituents of the hay are extracted by boiling, and this extract contains all the food elements required to grow the animal, besides being as digestible as milk. If the hay is cut early, when it has most soluble matter, and is of good quality, the tea will grow good calves; but this extract frequently has too small a proportion of albuminous and fatty matter. Yet if the hay-tea is boiled down so as not to contain too much water for the dry substance, calves will usually thrive upon it."[2]

Experiment with Hay-tea.—Professor Stewart describes an experiment which he made with hay-tea and other foods in calf-rearing. To each of five calves, thirty days old, he gave daily 2 gallons of hay-tea, in which ¼ lb. of linseed and ¼ lb. wheat middlings had been boiled. The experiment was con-

[1] *Feeding Animals*, 237.

[2] *Ibid.*, 246.

tinued for sixty days, with a gradual increase during the last thirty days of the middlings to 1 lb. The calves did remarkably well, gaining an average of a little over 2 lb. per head per day in weight. He also states that a similar experiment was tried by a dairyman who sold his milk for city consumption, yet desired to raise a number of calves. Here the results were even more satisfactory—the average daily gain in weight for sixty days being 2¼ lb.[1]

Making Hay-tea.—There is a knack in making all kinds of tea. There is a good deal in the manner in which this wholesome beverage for the calf is prepared. Some make it by merely pouring boiling water over long hay in a tub. A better plan is to cut the hay, as with a chaff-cutter, and boil it in the ordinary way for at least half an hour. Professor Stewart states that in his experiment mentioned above, he boiled hay cut ⅝ of an inch long, 3 lb. for each calf, half an hour, and then the short hay was raised upon a wire-cloth sieve over the kettle and drained, whilst the flax-seed and middlings were put into the kettle and boiled to a jelly.

It is important for tea-making that the hay should be cut young, when in full bloom, so that it may be nutritious and easily digested.

Where milk is scarce, the use of hay-tea in calf-rearing is to be commended.

Calf-rearing in Pure-bred Herds.

The methods of rearing calves in pure-bred herds does not vary quite so much as in ordinary stocks. In pure-bred herds the successful rearing of the calf is the first and main object. The utilisation of the cow's milk, apart from the upbringing of the calf, is as a rule a matter of secondary importance. The pure-bred calf, therefore, usually gets all the milk that is good for it. In the majority of cases, perhaps, it draws this directly from its dam, but the system of hand-feeding pedigree calves is also extensively pursued. In most cases the calf sucks its dam at the outset, and where hand-rearing is pursued it is taken away from the cow in ten days or two weeks—in some cases as early as its second or third day. Where the suckling method is followed, the calf is allowed to remain with the cow or have regular access to her till it is weaned at six or seven months old.

A Gloucestershire Shorthorn Herd.—In Lord Fitzhardinge's herd of shorthorns at Berkley Castle, Gloucestershire, the custom is to let the cows suckle their calves, the calves running with their dams and sucking at will for three weeks. The cows being milked between five and six in the morning, and at four o'clock in the afternoon, to take from them whatever the calves may have left. At the end of three weeks the calves are taken away and brought up by hand, the finger being given them for a day or two, if necessary, to teach them to drink out of the bucket. They are fed twice a-day, getting about a gallon of new milk each time, the quantity being slightly lessened if there is a tendency to scour. Care is taken never to gorge a calf with too much milk; the appetite and constitution of each youngster being carefully observed. Sometimes a calf three weeks old cannot beneficially take more than two quarts of new milk at each end of the day. Milk is continued till the calf is six or seven months old; but when it has been five or six weeks in this wicked world, it is allowed access to a little crushed oats, Indian meal, and barley-meal, given very sparingly at the outset, and not too finely ground, as calves do not so readily chew the cud when fed on finely ground meal.[2]

A Norfolk System.—In Mr Hugh Aylmer's large herd of shorthorns at West Dereham Abbey, Norfolk, Mr Housman tells us, "the calf at birth is allowed to remain with the dam, at least in the same box; but there is in the corner a little pen for the calf, in which it is kept, having the mother's companionship, though not unrestricted access to her, for the first fortnight. From that time the calf has a pen in some other house, sometimes in a box to itself, but oftener in a compartment in a house with other calves, and is taken to the mother twice a-day, morning and evening. If the mother is a deep milker, the herdsman takes from her as much

[1] *Feeding Animals*, 246.

[2] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 409.

milk as he finds she can spare, leaving plenty for the calf, which then comes in and clears the udder, so that the calf gets the richer 'strippings,' but does not satiate itself by taking too much after a day's (or a night's) fasting. . . . There is no inflexible rule, but usually the calf, if a heifer, is suckled about six months; if a bull, sometimes rather longer. As soon as the calf can be enticed to eat a little dry food, it has in its manger a mixture of crushed oats, oilcake, and ground maize (these ingredients varied in proportion, and one or more omitted so as to tempt the appetite), and sometimes a little cut cabbage or tares with the dry food; but it does not do much more than flirt with the manger until it reaches the age of six or seven weeks, when it begins to eat in earnest, and by the time it should be weaned, it is pretty well past the necessity of having milk, so that there is no checking of growth or loss of flesh after weaning. The quantity of milk, too, can be regulated by the quantity taken from the cow before the calf is turned in with her; and the calf is thus, by easy transition, relieved of dependence upon its mother." [1]

A Northumberland Shorthorn Herd.—In almost every instance, the cows in the Duke of Northumberland's shorthorn herd at Alnwick Park are allowed to suckle their calves. This plan, Mr Housman says, is found to be a safe one for both cow and calf, and since it was fully adopted, the loss of a calf at Alnwick Park has been very rare, and no shorthorn cow has died of milk-fever for many years. The calves remain with their dams for six or seven months, when they are weaned, in order to rest the cow before she has another calf.[2]

Scotch Shorthorn Herds. — The most general plan in Scotch herds of shorthorns is to allow the cows to suckle their offspring. Describing the practice in Aberdeenshire with the Sittyton shorthorn herd specially in view, Mr Housman says: "When the cow calves, the calf is tied up beside her; and for some time, until it is well able to take all her milk, the cow is regularly milked, *the calf sucking at the same time*, so that the cow cannot retain her milk. When the calf can manage all the milk, it is allowed to go loose about at will, one stall being left for the use of cow and calf. When the cows go out to the grass, the milk generally increases, and sometimes it is again necessary to resort to hand-milking to take away the surplus. After the calf is weaned, the cow is regularly milked three times a-day. Indeed, at all times, care is taken to relieve the cow of all her milk. The calves are trained to eat oilcake and sliced turnips as soon as possible, and are weaned at from seven to eight months old." [3]

Systems in Irish Herds.—There is no part of the country where calf-rearing is better understood than in Ireland. The prevailing system in Irish pure-bred herds is to let the cow suckle the calf. In Mr T. W. Talbot-Crosbie's herd of shorthorns at Ardfert Abbey, County Kerry, all the calves are suckled, and run with cows while these are on pasture. The bull calves are taken in as soon as they begin to be troublesome, and put into boxes *in pairs*, the same two being kept together until they are sold. The cows are brought in twice a-day to suckle the calves till weaning-time. The heifer calves are usually left with their mothers till the cows are housed in the autumn, but no calf is ever allowed to be with the cow after she is six months in calf. Food is given to the bull calves as soon as they are put into the boxes, but the heifers get no extra feeding until they are weaned. The first food, other than milk, given to calves, generally consists of pulped turnips, sweet-hay, and a mixture of linseed-cake, decorticated cotton-cake, oats, and bran, in the following proportions, divided into four equal parts: Two of linseed-cake, one of cotton-cake, and one of crushed oats and bran. There is no fixed rule as to quantity, except that the bulls are fed pretty liberally according to size, and the heifer calves sparingly.[4]

In Mr Richard Welsted's old-established herd of shorthorns at Ballywalter, County Cork, the rule is to let the cow suckle the calf for one day only, and to bring up the calves by hand-feeding,

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 415. [2] *Ibid.*, 395. [3] *Ibid.*, 388. [4] *Ibid.*, 422.

mainly with new milk, until they are well able to consume and live upon cut roots, hay, or grass, and roughly ground oats. To bring forward late calves, the suckling system is sometimes resorted to.

Hereford Herds.—In herds of Hereford cattle the almost universal practice is to let the calves suck their dams. The youngsters generally run with the cows on the pastures in the grazing season, and in the house they are either kept in a compartment with the cow, or in an enclosure by themselves, and brought to the cow two or three times a-day, most generally twice. If any cow gives more milk than is thought desirable for the calf, the cattle-man milks her at regular intervals. In Mr John Hill's herd at Felhampton Court, the calves, before the beginning of the grazing season, "are fed as soon as they can eat (they begin when a fortnight old to pick up a little), with hay, pulped swedes, or a few cut into finger-lengths, with a little cake and crushed oats. The allowance of cake and meal is increased as they get older, to half a pound each per day, and before the summer is over up to 2 lb. per day,"[1] the calves sucking their dams at the same time.

Polled Herds.—In the herds of polled Aberdeen-Angus cattle, suckling is the prevailing custom. The calves are trained, before being weaned, to eat other food, such as linseed-cake, hay, cut roots, bruised grain; and at the time of weaning they are fed and tended with the greatest care, so that there may be no retrogression. In some herds the calves are taken from the cows when about six weeks old, and thereafter brought up on new and skim milk, and gruel made chiefly from linseed-cake or oatmeal, or a mixture of these and other foods.[2]

General Notes.

Feeding Calves for Veal.—Large numbers of calves are slaughtered for veal, and these are of course forced with rich food from the very outset. New milk is the best of all foods for this purpose, although it may be to some extent supplemented by rich gruel, made perhaps from barley-meal or Indian-corn meal. Some give raw fresh eggs to veal-calves, which are generally allowed to suck the cow at will, or at least three times a-day. The usual period of fattening for veal is from six to ten weeks, and with the view of improving the colour of the flesh the calves are frequently bled. In fattening veal calves, most careful attention must be given to cleanliness, ventilation, and regularity of feeding.

Rearing Bull Calves.—As a rule, bull calves intended for sale for breeding purposes are fed more liberally than heifer calves. They are reared more largely upon new milk to begin with, the most general custom being to let them suck their dams for six, seven, or eight months. Then when other food is provided for them, it is usually of a richer and more forcing kind than is allowed to heifer calves. Gruel made from linseed or linseed-cake, oatmeal or barley-meal, is extensively used, and so is linseed-cake by itself or mixed with bruised grain. Malt is a favourite food with some experienced breeders in pushing on bull calves. Some breeders sweeten the food-mixture for young bull-calves with a little dissolved or diluted treacle. This should be used sparingly, however, if used at all—as food which, like treacle, is rich in sugar, is deleterious to the procreating properties of animals—that is if given in considerable quantities.

It is specially important that bull calves should have plenty of exercise and fresh air. If long shut up and highly fed on forcing food, they are liable to go wrong in the legs and feet.

Danger of gorging Calves.—Great care should be exercised in the feeding of calves in their tender days, especially during the first three weeks. At this time they should be fed sparingly rather than liberally. Many calves are lost by sucking or drinking more milk when they are quite young than their weak digestive system can readily dispose of. Whether the calf is fed by the hand or suckled by its dam, take care that it does not over-feed itself. Never let it suck or drink till it is quite satisfied—at any rate during its first three weeks. If the cow has too much milk for the calf, take away a little by the hand.

Referring to this point in his admi-

[1] *Hist. Hereford Cattle*, Macdonald & Sinclair, 274.

[2] *Polled Cattle.* Macdonald & Sinclair.

rable paper on "The Management of a Shorthorn Herd," Mr William Housman, one of our most reliable authorities on live-stock matters, says: "The theory is —and I believe it to be perfectly true— that many of the frequent and discouraging losses among young calves are caused by the allowance of too much milk at a tender age. The calves should be kept hungry—that is, never allowed to satisfy themselves—for the first three weeks of their lives. Scouring and indigestion, with consequent formation of hair-balls in the stomach, arise from too liberal or irregular feeding."[1]

Irregular feeding—long fasts followed by heavy meals of milk or other food—is quite as hurtful as, and of more frequent occurrence than, excessive feeding.

Many calves are killed by gorging with milk after a long fast—perhaps after a journey. When a purchased calf is taken to its new home it should be fed very sparingly for at least two days.

Does Suckling hinder Breeding?—By many experienced breeders it is contended that when the calf is allowed to remain with and suck the cow, there is a danger of the cow being longer in returning to the bull than if she were milked by the hand and the calf kept away from her. The subject has long been debated, and still opinion amongst leading breeders is sharply divided. The preponderance of opinion would seem to be that the danger, if such exist at all, is not serious; and this is confirmed by the fact that in pure-bred herds the suckling system is the one which prevails the most extensively. Some contend that it is the companionship of the calf, rather than the mere act of suckling, which retards the cow in breeding again; hence some who practise the suckling, systematically keep the cows and the calves separate from each other except at feeding-times.

Mr Housman made a special point of investigating experience and observation upon this subject amongst breeders of shorthorns throughout the kingdom, and he was quite unable to account for the divergence except by differences in local conditions of soil and climate, by the assumption that certain districts are more favourable than others to the breeding propensity and reproductiveness of cattle. In some herds it has been found that cows rarely return to the bull until after their calves are weaned. In others the sucked cows come round as early and as regularly as those milked by the hand.

Licking and Rubbing beneficial.—Many skilled breeders systematically let the newly dropped calf be licked by the cow. And there is more in this apparently small matter than is generally supposed. "The bloomy appearance of suckled calves is partly due to this motherly attention; and the licking along the calf's spine, which the cow, with her rasp of a tongue, gives her calf immediately after birth, has evidently an important meaning. All careful managers, when the calves are not reared by the cow, take care to imitate this process, rubbing well over the spine with a wisp of straw. This not only dries the calf and prevents its taking cold, but evidently strengthens it; and the calf, if a healthy one, responds to the rubbing by vigorous efforts, soon successful, to gain its feet."[2]

Weaning Calves.—Weaning is usually a critical event in calf-life. In dairy and ordinary stocks, where only a small portion of the milk is given to the calves, the youngsters are weaned when very young. The process may be said to begin in some cases at the end of the second week, when some skim-milk or gruel is substituted for so much of the new milk. In pure-bred herds, and wherever calves are reared largely on milk, weaning is generally completed in the sixth, seventh, or eighth month, after which the calves are fed similarly to the other animals.

Now in the weaning of calves there is scope for the exercise of the utmost skill and care. If success is to be attained, both skill and care are essential. Prepare the young animal for the weaning —the complete withdrawal of its mother's milk—by feeding it partially for some time before with such food as will form its main support after it has been weaned. Let the milk be lessened, and the other

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 388.

[2] *Ibid.*, 428.

food gradually increased in quantity, so that the transition may be effected almost imperceptibly. The more carefully and intelligently this is done, the more satisfactory will be the result in the calf. The amount of milk allowed to a suckled calf may be regulated by drawing away as much of the cow's milk by hand as may be desired, and at last, just before final weaning, the calf may have access to the cow only once a-day.

There is perhaps no better food for calves at weaning-time than good linseed-cake—from 1 to 2 lb. per day, and a few sliced turnips or mangels, and fresh well-made hay. If accustomed to this fare before being entirely deprived of their mother's milk, they will be found to pass through the ordeal of weaning without any loss in condition or delay in progress.

Diseases of Calves. — *Scouring* — sometimes called white skit or white scour — is the most prevalent ailment among calves. It is generally caused by improper feeding, and may as a rule be cured by giving 2 ounces of castor-oil, or an egg beaten up shell and all, followed by tablespoonful doses of *calf-cordial*, prepared of the following: prepared chalk, 2 ounces; powdered catechu, 1 ounce; ginger, ½ ounce; opium, 2 drachms; peppermint-water, 1 pint. Oatmeal or linseed gruel should be the main food for a few days.

Calves also suffer frequently from *constipation*. This will be relieved by giving 1 ounce of castor-oil beaten up in the yolk of an egg, with a very little ginger, about 1 scruple, repeating the dose if necessary.

Eggs for Calves.—An effective "pick-me-up" for a calf that is not eating or thriving as well as could be desired is a raw egg beaten up and added to the milk. Some beat up the egg shell and all, others think it preferable to withhold the shell.

Setoning.—A seton is a piece of string or tape passed through a certain part of the body, with the object of either drawing an abscess, acting as a counter-irritant, or for the purpose of inoculation. As a prevention against black-leg, or quarter-ill, it is a useful custom to insert a seton in the calf's brisket in the spring. It is considered desirable to soak the seton in some irritant such as the following embrocation—viz., hartshorn, 1 ounce; turpentine, 2 ounces; spirit of camphor, 2 ounces; laudanum, ½ ounce; olive-oil, 6 ounces.

Castrating.—The male calves can be most easily castrated when a few weeks old. They can then be cut standing, by twisting the tail around one hind leg. Stand behind the calf, cut through the bag, twist the stone several times, and scrape the cord closely through with your finger-nails or a blunt knife. When the calves are several months old they must be cast. This may be done by tying the hind-legs together with a rope, placing a halter round the neck, taking the shank end of the halter and running it through the rope that unites the hind-legs, tying it back, passing it through the portion that is around the neck, and drawing the legs tight, then fastening the rope. The fore-legs can be held by a man. The stones may then be removed by the clams and hot iron, as in the case of the horse—place the stone in the clams, and with a red-hot iron saw the cord slowly through close to the clams.

SHEEP IN SPRING.

The anxieties of the spring — the hopes and the fears — are as great to the flock-owner as to the cattle-breeder. It very often happens that the heaviest part of the winter weather has to be gone through in spring. Severe snow-storms frequently occur in February, and occasionally stretch into March, causing much anxiety, and it may be serious losses, to flock-owners, by deaths and by outlay for extra feeding and management.

Sheep in Spring Storms.—As to the treatment of sheep in stormy weather

in spring, the information given under the heading of "Sheep in Winter" should be consulted. The particular kind of extra food to be given to the sheep in a spring snowstorm will depend mainly upon the supply on the farm and the sort of food cheapest and most easily obtained at the time. This one word of caution we would repeat, Do not too long delay hand-feeding if such should be necessary —do not postpone extra feeding till starvation has done its work of mischief. At such a crisis *timely* rather than liberal feeding is the essential point.

THE LAMBING SEASON.

At this season of the year lambing is the all-absorbing topic of interest with the sheep-farmer and the shepherd. No one who has not lived on a sheep-farm can conceive what the advent of the lambing-time brings to the chief actors in flock management. It arouses a depth of interest and a ceaseless anxiety not experienced at any other period of the year. It is the time in which, above all others, good or bad management *tells* —when every hour of carelessness may rob the flock of the lives of valuable animals.

And the seriousness of the lambing season is nearly allied to sentimentality; for while the faithful shepherd is toiling day and night in the lambing-pens, he is even then cheered by a foretaste of the unspeakable joys which come alike to the owner and the tender of the flock from the sight of thriving "lambs at play." It may be—we fear it is, although one is loath to believe it—that the hard utilitarianism of the present age is depriving pastoral life of much of the sentiment and poetry which gilded it in the past.

Poetry of Pastoral Life.—We are heart and soul in sympathy with Professor Wrightson when he says: "There is genuine poetry in pastoral life which it is sad to lose entirely. Nevertheless, agricultural science and literature are between them rapidly taking the romance out of it. Perhaps we should add, hard times, and the vital importance of making things pay. Still, it is a pity to lose the faculty of discerning the beauty of the dewy eve and rising moon, or listening as the amorous thrush concludes his song; or only to think of the price of mutton and of wool, or of lambs as fore and hind quarters.

> "'The haunt o' Spring's the primrose brae,
> The Summer's joys the flocks to follow;
> How cheerie through the shortening day
> Is Autumn in her weeds o' yallow!'

"The sweetness of pastoral life is going. It is disappearing under the influence of commercial enterprise, the spread of science, and the difficulties of competition. We also ourselves are victims to utilitarianism, and must plead guilty to sharing in the universal want of sentiment even when birds rejoice in leafy bowers and bees hum round the breathing flowers; or when within yon milk-white hawthorn bush, among her nestlings sits the thrush. One is sometimes inclined to wonder if steam-power and chemical manure, pedigree stock and iron fencing, weigh-bridges and milk registers, will ever compensate us for the loss of the fresh and simple country life of our forefathers. It is useless to repine, and perhaps the best thing we can do is to cherish those pleasurable feelings with which we may still view the flock spread o'er the down, or listen to the varied tones of the sheep-bell; and to cultivate more of personal interest and affection for our domesticated creatures. There is no doubt that the humble dairyman, the carter, or the shepherd, obtain more enjoyment from watching and tending their charges than do their masters; and the pleasures of farming might be greatly enhanced by devoting more personal attention to our live stock, and studying their habits. Love of animals may be cultivated, and with it comes an interest in the wild creatures which surround us."[1]

Assuredly the kindly interest here inculcated has a practical bearing upon the material wellbeing of the flock-owner, who may do much to encourage his shepherd by sympathetic countenance and intercourse by the side of the flocks. And a good shepherd is well worthy of all the encouragement that can be given to him.

[1] *Live Stock Jour.*, Jan. 1889, 42.

A Good Shepherd. — A shepherd whose unwearied attention and consummate skill become conspicuous at this critical period of the flock's existence, is an invaluable servant to a stock-farmer. His services, in fact, may be worth far more than the amount of wages he receives. Such a man will save the amount of his wages *every year*, when compared with the losses sustained by the neglect of an unskilful shepherd, especially in a precarious season, when, by treating the ewes and lambs in the most proper manner under the circumstances, the lives of many are preserved that would otherwise have been lost.

The Modern Shepherd.—As a class of men the shepherds of the present day are surpassed by none of their fellows on the farm for intelligence, efficiency, or faithfulness. They are undoubtedly, as a rule, better informed, if not more trustworthy, than the shepherds of former times. In many instances we have known, their success in treating their flocks at lambing-time has been remarkable. Yet the best of them need all their wits about them in the height of lambing, and in bad weather may sustain numerous losses in spite of their utmost efforts.

Skilful and Attentive Shepherds. —Some shepherds are as attentive as could be wished, but lacking in skill. They may have their ewes in too high condition for lambing, and may be over-anxious and over-ready to assist in difficult cases of lambing—thus, through want of skill, causing the loss of both ewes and lambs. Other shepherds, again, are sufficiently skilful, but are wanting in attentiveness. Of these two sorts of shepherds—the attentive and the skilful —the skilful is the safer, as it will usually be easier for the master to enforce attentiveness than to inculcate skill—that is, if the skilful shepherd is not a positively careless fellow, in which case he should not be in this position at all.

A Perfect Shepherd.—It is only by the union of both qualities that a perfect shepherd is constituted—preventing evils by skilful attention, and curing them by attentive skill. Even with such a perfect shepherd losses will happen, but they will be no fault of his: disease will prove mortal to sheep at lambing, which even the most skilled veterinarian cannot prevent. His acuteness will perceive a sheep affected long before any one else can detect it; but it is not to be expected of any shepherd to treat many of the diseases of sheep successfully when a veterinarian is not to be found.

Preparations for Lambing.—The cautious shepherd will have several preparations attended to before lambing begins. He will see that sufficient shelter is provided—on arable land—either in permanent or temporary lambing pens,—will have conveniently at hand supplies of extra food, such as turnips, cabbages, hay, &c., also of straw for litter, and will see that his medicine-box is replenished to meet emergencies. He will have a good lantern, such as shown in fig. 117, in readiness to guide him through the pens at night, and likewise a piece of blanket in which to wrap a weak lamb. In many cases the shepherd will have to spend the night beside the lambing-pens, and he must therefore have his own bed in order, either in his separate hut, or in a corner of the lambing-shed. There should be a fire in the shepherd's compartment, and some coffee or tea will be useful. All these essentials should be in readiness, and not have to be sought for when the active and critical work of lambing begins.

Classifying Ewes for Lambing.—Ewes are drafted into the lambing fold or ground in lots as they are expected to lamb. The tups are usually left among the ewes for six weeks. After two weeks' service the tups are marked with, say, red paint on the breast, and this, at the end of two weeks, is changed to blue paint. The marks of paint on the breast of the tup mark the served ewes on the rump, and thus their time of lambing is ascertained. The in-lamb ewes unmarked are first taken in for lambing, then those with red marks, and lastly those with blue marks. It is well to have the ewes on the lambing-ground quite a week before their lambs are due, as early parturition is frequent.

In many cases the order of marking service is the reverse of the above, the unmarked ewes being the last to lamb.

Lambing Folds or Pens.—Custom

varies greatly in the providing of shelter for lambing. On many farms there are elaborate and costly lambing sheds and pens built of stone and lime. On others the lambing-pens are merely temporary erections, formed, perhaps, of hurdles and straw; while in many cases no lambing-pens of any kind are provided. Costly erections are not necessary, and therefore undesirable, as all unnecessary outlays are. Lambing-pens of one kind or other, however, should be provided upon all farms carrying breeding-sheep, and for all kinds of sheep, whether the hardy mountain breeds or the more tender southern varieties. Let the character of the shelter be suited to the farm, the locality, and the breed of sheep. Little roofed space may suffice, but there should be a dry bed and shelter from the prevailing winds. The weather may be so favourable as to make it unnecessary to put any of the ewes and lambs under roof, yet the means of doing so should exist. The sudden occurrence of a storm without proper shelter being at hand for ewes with very young or tender lambs, might result in serious losses.

The Old-fashioned Shed.—Professor Wrightson, in the paper already quoted, says that shelter must be provided for the ewes at lambing-time. He mentions two descriptions of enclosures for lambing-ewes. One is the old-fashioned permanent shed, for which the rick-yard has often been employed. The advantages of this system are, that the flock is near home, and that the rick-yard is a protected enclosure, which, when well littered down and fenced with thatched hurdles, forms a very suitable place for the purpose. In some cases there are seen special walled enclosures, furnished with accommodation for the shepherd and shedding for the ewes. The shedding is most conveniently divided into coops by means of hurdles, and in such a shed ewes will lamb safely and comfortably. On large sheep-farms this system is objectionable on account of the distance between the flock and their food.

The Modern Fold.—The more general plan now is to construct a pen near to where the ewes and lambs are to turn out after lambing. The position of the pen, says Professor Wrightson, should have been fixed during the previous summer, and have determined the situation of certain hay and corn ricks. As threshing proceeds, the corn-ricks yield straw-ricks, which are made long, and placed so as to secure the greatest amount of shelter from the wind. A gentle slope towards the south is the best site, and in close proximity to a field of swedes or of late turnips.

The enclosure consists of a double row of hurdles, stuffed between with straw, and kept firm by means of a few posts and rails. About 2 feet from the outside wall, and on the inside, are driven 6-feet posts carrying a head rail or plate, and, resting on this plate and upon the outside hurdles, with a sufficient run or slope, thatched hurdles are fixed; thus forming a continuous narrow shed, which is again divided by hurdles into coops or cells. These coops are best open to the south and east, and backed to the north and west; and in such a position ewes and lambs lie warm even in the severest weather. Outside these cells, and inside the enclosure, the space is divided by hurdles into four or five good-sized yards, and a straw-rick ought to occupy a central position with reference to the entire space. The shepherd's portable house is drawn up at a convenient distance, and with such a fold we may look forward to the throes of lambing with a feeling of confidence and security.[1]

Fold for 300 Ewes.—In his paper on the treatment of Border Leicester ewes and lambs, Mr A. S. Alexander gives the following description of a lambing-fold for about 300 half-bred ewes: "A small field of half an acre is chosen behind the homestead. At the north side there is a high stone wall, and on the east a thorn hedge, which effectually breaks the effect of the east winds. Along the north wall are erected a row of twenty houses, 'parricks' or pens, the roofing of which is made by fixing timber from the top of the wall to the posts which form the doors and fronts of the pens. One door serves for two pens, there being in the interior a middle division which does not quite come to the same line as the walls in front. The door is closed by means of a small hurdle or 'flake,' which

[1] *Live Stock Jour.*, 1889, 65.

moves between the partition and the inside of the walls.

"The roof is thickly thatched with rye or wheat straw, tied in bundles, and on the outside or front, bunches of straw resembling sheaves are set on end, so that their tops meet the thatch; and when fixed in this position by means of 'tarry' string or old sheep-netting, a most effectual covering is made, the straw materially adding to the warmth during the cold nights so commonly prevalent in March. This row of pens forms the north side of a rectilineal figure. On the east is the hedge; and to form the other two sides west and south, a fence of larch posts, with three spruce rails, is erected of the same height as a common fence. To make this enclosure as comfortable as possible, bunches of straw are fixed all along the inside of the fence and hedge, and when fixed in position, form as it were a solid wall of straw, which is quite impervious to the strongest wind.

"The enclosure which is called the court is provided with two gates—one for driving the ewes in at the evening, at the west end, and one at the east end, where ewes and lambs are turned into a 'seed' field after a day or two. There is also a little gate formed of two bundles of straw, at which the shepherd enters at night."[1]

Permanent Lambing-shed.—A substantial permanent lambing-shed erected on the farm of Crookhouse, Lanton, Northumberland, is also described by Mr Alexander: "All the pens are erected under one roof of larch, timber, and slate, and enclosed in front and behind by substantial walls of stone. The partitions between the pens themselves are constructed of larch hurdles, fixed at each end to larch uprights, which at the same time support the roof. Each set of pens is divided by a passage communicating with the outside court, where the unlambed ewes lie at night.

"On entering a passage we have three pens on each side, provided with gates hung on hinges, and fastening by means of an eye and draw-bolt. A few pens are made six feet square, so that should the shepherd have ewes with twins, he may have ample accommodation for them, should he not require the third lamb for another ewe. There are fifty-four pens, and the reason for such a large number is that, should severe weather—as a snowstorm—come on during the season, the ewes may be penned instead of lying out.

"By having a number of doors in the lambing-shed instead of a few, the lamber is enabled to house the ewe at the point nearest the place where she lambed. To make it all the easier for him, the pens are constructed round three sides of the square court, so that at whatever part of the court a ewe lambs he has shelter at hand. A covered court enclosed is also in connection with these lambing-pens, into which on stormy nights ewes and gimmers having single lambs are placed. There is also a storehouse for food under the same roof."[2]

Lambing Shelter on Hill Farms.—As a rule hill farms are deficient in lambing shelter. On these the lambing is delayed till so late a period in the season—from the middle of April till the end of May—and the mountain breeds of sheep are so hardy, that farmers are apt to trust too much to the clemency of the weather and the hardiness of the sheep. The more careful farmers have numerous small pens or "keb-houses" erected on the lambing-ground, so that there may be plenty of protection for both ewes and lambs from severe storms. On many farms, however, little attention is given to this, and as the result the losses of young lambs, and even of ewes, are often exceedingly heavy. This neglect is all the more reprehensible from the fact that comfortable lambing pens or huts might be formed at nominal expense and very little trouble. With some hurdles, or a few boards, cuttings of turf, and perhaps a little straw, temporary shelter may be provided by which the lives of many lambs might be saved. And it is equally important that the shepherd should provide himself with some extra food, such as hay, roots, and corn, with which to nourish weakly ewes confined for a time in these lambing-huts.

Lambing Hospital.—A few pens in a corner of the lambing-fold by themselves should always be set apart for hospital purposes. In these, weakly ewes

[1] *Trans. High. and Agric. Soc.*, 1882, 146.

[2] *Ibid.*, 1882, 148.

and lambs may be made specially comfortable, the ewes receiving palatable, nourishing food, or such remedial treatment as best suits their peculiar ailments. Many careful farmers have such hospitals formed at some convenient and well-sheltered spot in a field quite independent of an ordinary lambing-fold. They may be formed of hurdles and straw at very little trouble and expense, and would be of great benefit wherever a breeding flock is kept.

Accessories to the Fold.—It is often difficult to keep the floor of the lambing-fold dry. It is a good plan to have the floors of the roofed pens raised by a layer of gravel or burnt clay; and the whole should be comfortably littered with straw. The stacks of straw and hay in the centre will add greatly to the comfort of the fold. A store of roots should be at hand, and so also should be a well-filled corn-bin, with a number of small feeding-boxes which can be placed here and there for the ewes. Care should be exercised in placing the shepherd's hut, root-store, and hay and straw stacks, so as to provide the greatest possible amount of shelter.

Supplementary Shelter.—In addition to the regular lambing-fold it would be well to provide additional shelter in the form of small covered pens or huts at convenient well-sheltered parts of the farm, where weakly ewes and lambs might find comfort during a storm without having to be brought into the fold. These might be very cheap and temporary erections, constructed by the shepherd; and they would be specially useful on hilly farms, or wherever the ewes are not systematically brought into a fold for lambing. With several of these supplementary pens placed conveniently over the farm, odd ewes and lambs would be more easily provided with protection from sudden storms than if they had all to be driven to one central fold. The importance of even one night's shelter to a young lamb may be very great, often saving it from death, and setting it on its legs.

Shepherd's Hut.—This should rest on wheels, and may be made of iron or wood. It should be large enough to hold a bed for one man, a small table and chair, a cupboard for the shepherd's food, and the medicine-case or bottles for the sheep, and of course a fireplace. Fig. 246 represents a convenient portable shepherd's house made of corrugated iron by the Redcliffe Crown Galvanised Iron Co., Bristol.

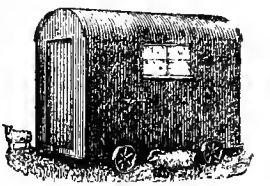


Fig. 246.—*Shepherd's house on wheels.*

Shepherd's Medicine-chest.—In many cases shepherds are now provided with medicine-chests furnished with a considerable variety of medicines and stimulants, comprising laudanum, linseed-oil, castor-oil, spirits of nitre, Epsom salts, powdered ginger, powdered chalk, tincture of aconite, carbolic acid, Gallipoli oil, and whisky or brandy, &c., &c. Excessive physicking, however, is not to be commended. Drugs should be used with caution—only when necessary, and then as promptly as possible. In the lambing-pen carbolic acid and Gallipoli oil are most valuable agents, for they are reliable preventives of inflammation after lambing.

Symptoms of Lambing.—These are, enlargement and reddening of the parts under the tail, drooping of the flanks, patting the ground with the feet, and desire for separation from their companions, stretching frequently, exhibiting restlessness by not remaining in one place for any length of time, lying down and rising up again as if dissatisfied with every place, bleating as if in quest of a lamb, and appearing fond of the lambs of other ewes. In a few hours, or shorter time, the immediate symptom of lambing is the expulsion of the bag of water from the vagina, when the pains of labour may be expected to come upon the ewe immediately. When the pains are felt, she lies down and presses with earnestness, changing one place or position for another, as if desirous of relief.

Assistance in Lambing.—Up to this time not a hand should be put upon her, nor, as a rule, until the yellow hoofs of the fore-feet of the lamb, and its mouth lying upon them, are distinctly seen to present themselves in the passage. When time has been given, and the ewe

is not able to expel the lamb by her own exertions, the shepherd renders assistance before her strength fails by unavailing straining. Before giving assistance to a ewe while lambing, the shepherd should smear his hands as well as the vagina of the ewe with "carbolic oil"—that is, a mixture of 1 part of carbolic acid to 10 parts of pure olive-oil.

The exact moment for rendering assistance can be known only by experience. It is necessary to watch and wait, for a hasty parturition often superinduces inflammation, if not of the womb, of the external parts of the ewe. If the labour is unusually protracted, the ewe should be examined, and if the lamb is found to be in its natural position—with its head resting on its two fore-legs—a little more time may be given. Tedious labour often terminates in an easy birth. In nine cases out of every ten of natural presentation the ewe will lamb without assistance. But the ewe should not be allowed to thoroughly exhaust herself before receiving assistance.

When assistance must be rendered, the ewe is taken hold of as she lies, and laid gently over upon the ground on her far or right side, with her head up the hill, where the ground has an inclination. To save her being dragged on the ground when the lamb is being extracted, the shepherd places the heel of his left foot pressing against the rump of the ewe, and kneels on his right knee on the ground, pressing against the lower part of her belly, having the body of the ewe below his own body, between the heel and knee. Having his face towards the tail of the ewe, and both his hands free, he first proceeds to push out *from* him, with both hands, one leg of the lamb and then the other, as far as they will stretch; then seizing both legs firmly above the fetlock-joints *between* the fingers of his right hand, he pushes the legs from him rather downwards from the ewe's tail, with considerable force, whilst by pressing upon the space between the tail of the ewe and the head of the lamb *towards* him, with the lower edge of his left hand, he endeavours to slip the vulva of the ewe over the cantle of the lamb. The action of both hands must be made simultaneously with the strainings of the ewe, only to assist her, and keep good what is obtained at each strain, and not to tear the lamb from her prematurely by force. Whenever the lamb's head is clear, the shepherd seizes the upper part of the neck behind the head with his left hand, the right hand still holding the legs, and pulls out the body with ease. The lamb is then placed at the ewe's head, for her to lick and recognise, which she will instantly do, if her labour has not been severe. If the labour has been very severe, she will likely become sick, and be careless of the lamb as long as the sickness continues, which is evinced by quick, oppressed breathing.

If the pains have been sharp, and this her first lamb, and she is not overcome by sickness, the ewe may probably start to her feet, and run away from the lamb. The attempt at escape must be prevented, and the end of the tail of the lamb put into her mouth, to make her notice it.

The extraction of a lamb, as thus related, is done by a shepherd who has no assistant. When he has, he adopts another and more easy mode for the ewe and himself. The assistant holds the ewe upon her side, in any way the most easy for her and himself, to prevent its body being dragged along the ground while the shepherd is extracting the lamb. In doing this, the shepherd places himself behind the ewe, and, on ascertaining the position of the lamb, pulls its legs *towards* him, whilst the assistant endeavours, by the pressure of the side of his hand below the tail, to make the vaginal membrane pass over the lamb's head, which when accomplished, the shepherd seizes the back of the neck by his right hand, and, holding the legs still in his left, takes away the lamb as quickly as he can, and places it before the ewe.

There is great difference in the disposition of the ewes themselves to assist in the lambing. Some, when they find they are assisted, give themselves little trouble; others strain with vigour from first to last; and some only strain at long intervals. A ewe that strains strongly and continuously will become sooner exhausted than one that takes the matter more leisurely. In the case of the straining ewe there is greater danger in neglecting to make examina-

tion of the presentation in time, before the ewe has become exhausted.

A Second Lamb.—If she continues to lie on her side, her abdomen should be felt, to ascertain if there is another lamb to come. If there is, the pains accompanying the passage may have been the cause of her carelessness for the first lamb. If the second lamb is in a natural position, it will most probably, by this time, be showing itself in the passage. If so it be, it should be taken away at once in the same manner as the first, and the ewe, feeling the attempt, will at once assist on her part by straining.

The existence of a second lamb is worth attending to immediately on another account—some ewes become so engrossed with the first lamb, that the pains attending the second are neglected for a time. When a second lamb is found in her, she must be watched, that whenever it comes into the passage it may be taken away; but unless it actually makes its appearance there, it should not be attempted to be taken away.

Should the second lamb not make its appearance in a reasonable time, it may be suspected that the lamb is either dead or not in a natural position, and examination should be made by the fingers into the state of the case. In cases of suspected twins, some make an examination to ascertain if they are presenting themselves separately. If a complication is probable, the hand will have to be introduced to effect a separation of the twins by bringing one forward to the passage. A dead lamb is easily known by the feel, and should be extracted immediately; but should the lamb be alive, and make no appearance, it may be necessary to introduce the hand to ascertain its position. Before the hand is introduced, it should be smeared with the mixture of carbolic acid and oil.

False Presentations.—Cases of difficult lambing generally arise from the presentation of the lamb in some false or abnormal form. The natural position of the lamb in the passage is upon its belly, with its head resting upon its two fore-legs. The false or abnormal presentations are of course variations from this position. The most recent, and one of the fullest definitions of abnormal presentations, is that given as follows by Professor Wrightson, whose sound advice should be considered carefully by flock-owners and their shepherds:—

"1. One fore-leg only presented with the head lying upon it. In this case it is difficult for a ewe to lamb without help. The operator will endeavour to get hold of the missing limb, and, bringing it forward into its proper position, deliver the ewe. The best manner of doing this we shall consider after passing in review the principal abnormal presentations.

"2. Both fore-legs lying back, the head alone being presented. In this position the ewe must have assistance, as birth without it is impossible. The head must be pushed back, the legs brought forward, and the lamb extracted.

"3. The head slipped down between, or on one side of, the fore-legs. This must be set right by bringing the head into its natural position above the fore-legs, and extracting the lamb.

"4. A broadside presentation, in which case the broad side of the lamb is found within the uterus, and of course no progress can be made until the hand and forearm of the operator are introduced and the fœtus is turned and brought into position.

"5. The fœtus on its back, in which case a similar manipulation must be employed as in the last case.

"6. A breech presentation. If the hocks are doubled, the breech of the lamb must be pushed forward, and the hind feet brought up. The lamb is then pulled away backwards without turning.

"7. The fœtus too large, or the passage too small. This is a troublesome case, sometimes involving the loss of the lamb, and occasionally of the ewe. Shepherds sometimes are obliged to carefully introduce a knife and cut off the shoulders, and remove the fœtus piecemeal. More commonly by patience and by exerting a good deal of strength the lamb is safely born.

"8. Monstrosities are not uncommon, most seasons providing examples of lambs with five legs, headless lambs, fusion of two lambs into one, &c. These cases are puzzling, and require special treatment, and when such malformations are presented there need be no

hesitation in employing the knife for their removal.

Assisting in Lambing. — "Having given all the possible unnatural presentations likely to be met with, I shall next explain how assistance ought to be rendered to a ewe in distress. In all cases great care and gentleness are requisite, and all roughness or hurry should be avoided. The hand should be anointed with fresh lard or oil, and the finger-nails must be short (shepherds' nails always are). The hand must be compressed into as narrow a space as possible and gently introduced. In giving assistance the operator should draw the lamb in accordance with the natural pains of the ewe, and wait for her to pain. Assistance given at that moment is useful; but if force is used during the intervals of the labour-pains, the muscles of the uterus are excited, and the result is the early exhaustion of the mother. Again, in using force the fœtus should be drawn downwards towards the hocks of the ewe, and the operator need not be afraid of using his strength when the fœtus is once brought into a proper position."[1]

One Fore-leg Presentation.—In regard to the difficulty of one fore-leg presentation, Mr George Brown, Watten Mains, Caithness, says: "If the lamb is well forward in the passage, it is much easier, and often safer, to bring the lamb away as presented, than to attempt pressing back the head to get forward the other foot."

Cæsarean Operation.—The lamb is sometimes in the Fallopian tube, from some cause or other not coming into the womb after conception. Cases of this nature can only be managed by the Cæsarean operation — taking the lamb out of the ewe's side. In cases of this kind, while the lamb may be saved, the ewe, unless a good deal of care and skill are used, is very liable to be lost.

The hardier the breed the rarer the necessity for assistance in lambing. In flocks of Blackfaced and Cheviot sheep, thousands of ewes lamb every season without the slightest assistance.

Inflammation after Lambing.—Unless the utmost care is exercised there is great risk of losing the ewe after a case of hard labour, by "bearing" or "straining"—after pains— and inflammation. Formerly the rate of mortality from inflammation after lambing was very high, but it has been abundantly proved that by timely treatment the danger may be effectually averted. It has already been pointed out that in all cases the shepherd, before assisting a ewe, should smear his hand in a mixture of carbolic acid and olive or Gallipoli oil — about 1 part of the former to 10 parts of the latter. Then, after the removal of the lamb, about two tablespoonfuls of the carbolic acid and oil should be poured into the womb, while any of the external parts which seem inflamed should be smeared with the same mixture. This treatment should be repeated every three or four hours, as may be found necessary. The strength of the carbolic mixture should be regulated — from 5 to 20 parts of Gallipoli oil to 1 of carbolic acid — according to the symptoms of the case. Where the symptoms of inflammation are serious, a strong mixture should be applied promptly and frequently. The efficacy of this simple and inexpensive treatment in preventing after-birth inflammation is remarkable—so much so indeed, that if it is applied in time, immediately after birth in hard cases of labour, and in all cases upon the faintest indication of after straining or inflammation, complete prevention may be expected in ninety-nine cases out of every hundred. It should be mentioned that the credit of discovering this invaluable preventive belongs to Mr Charles Scott, author of 'The Practice of Sheep Farming.'

Rotten Turnips causing Inflammation.—Referring to the occurrence of inflammation among ewes after lambing, Mr James A. Gordon, of Arabella, states that he had found the tendency to inflammation and mortification much greater when ewes were fed on turnips of which a good many were in a half-rotten condition. The best corrective in this case, he says, is to remove the ewes to a field where they can get plenty of young clover, and will receive only a few roots, nothing being so suitable for ewes and their young lambs as fresh young grass.

Inflammation Infectious.—Referring to the infectious character of inflammation in ewes after lambing, Mr George Brown,

[1] *Live Stock Jour.*, 1889.

Watten Mains, Caithness, says: "When a case of inflammation does occur, it is absolutely necessary to separate the ewe from the flock, and have the place she lambed at thoroughly disinfected. The disease is most infectious, and will attack all ewes which lamb after the first case if they come into contact with the contagion. The shepherd, if he has touched the affected ewe, must be very careful to wash his hands in either turpentine or carbolic oil, and even change his clothes before touching another ewe; while ewes which die of inflammation should be skinned by some one else, not by the shepherd.

"*Oats* are a fruitful cause of inflammation in ewes, as ewes fed largely on them become full and hot-blooded at a critical time. Feeding on oats should therefore be discontinued a few weeks before lambing, and cake or bran, or extra turnips, given instead."

After Lambing.—When lambing has taken place in the day, in fair weather, the ewe with her lambs are best at liberty within the enclosed area of the lambing-ground; but in rain or snow, and at night, she should be taken into the shed, and kept there for some time until the weather proves better, or she has recovered from the effects of the lambing. In the day-time, it matters little for lambs how cold the air is, provided it be dry. It is considered a good sign of health when a lamb trembles after birth.

Cleansing.—The cleansings or placenta generally drops from the ewe in the course of a very short time, in many cases within a few minutes after lambing. It should be carried away, and not allowed to lie upon the lambing-ground.

The Lamb.—The lamb is fondly licked by the ewe at first, and during this process the youngster makes many fruitless attempts to gain its feet, and it is truly surprising how very soon after an easy birth it will stand. The moment it does so, its first effort is to find out the teat, expressing its desire for it by imitating the act of sucking with its lips and tongue, then uttering a plaintive cry, and wagging its still wet long tail. There are various obstacles to its finding the teat at first—the long wool on the ewe's flank hides it—that on the udder interferes with it—and what is still more tantalising, the intense fondness of its mother urges her to turn herself round to it, in order to lick it with her tongue, muttering affectionate regards, while her wheeling about removes the teat, the sole object of the young creature's solicitude. When at length a hold of it is obtained, it does not easily let it go until satisfied with a good drink, which is indicated by its full flanks. When a fond ewe has twin lambs, one can easily obtain the teat while she is taken up in caressing the other. This is the usual behaviour of strong lambs; and on once being filled with warm milk, they increase in strength rapidly, and are soon able to bear very rough weather.

Assisting Lambs to Suck.—But after a protracted labour, the lambs may be so weakly at first as to be unable to reach the teat by their own strength. They must then be assisted, and the assistance is given in this way: turning the ewe over upon her rump, the shepherd kneels upon the ground on his right knee, and reclines her back against his left leg, which is bent. Removing any wool from the udder by the finger and thumb if necessary, he first squeezes the wax out of the teats, and, taking a lamb in each hand by the neck, if twins, opens the mouth of each with a finger, and applies the mouth to a teat, when the sucking proceeds with vigour. A young ewe or gimmer is apt to be shy to her first lamb, but after being suckled, either in this or the natural way, she will rarely forsake her offspring.

When lambs do not succeed at once in finding the teat, the shepherd should soon give the lamb its first suck in this way, which not only saves it much trouble, and gives it strength, but affords himself a favourable opportunity of examining the state of the udder. The first good and early suck to a lamb imparts a strength to it beyond expectation.

Gimmers often have so scanty a supply of milk, that it is expedient for the shepherd to support their lambs partially on cow's milk until the requisite supply appears, which will be partly induced by suckling, and partly by nourishment of succulent food.

Hand-feeding Lambs.—When the shepherd has lambs to support for a

short time, he should supply them with cow's milk at regular hours, in the morning and evening, immediately after the cows have been milked, and should see the lambs suckled by their mothers during the day, as also that the ewes have a sufficiency of milk. The dairymaid should put the cow's milk for the shepherd in bottles, when the cows are milked in the morning and evening, and he should feed the young lambs while the milk is warm from the cow. The feeding is done in this way: Sitting down, the shepherd takes a mouthful of milk from a bottle, and, holding up the mouth of the lamb open, he lets the warm milk drop into it in a small stream from his mouth, which the lamb drinks as fast as it comes; and thus mouthful after mouthful until the lamb is filled. The auxiliary supply of milk should be withheld whenever the ewe can support her lambs.

Removing Ewes and Lambs.—Ewes are kept on the lambing-ground until they have recovered from the effects of lambing, the lambs have become strong, and the ewes and lambs are well acquainted with each other. The time required for all this depends on the nature of the lambing and the state of the weather: the more severe the lambing, and the more broken the weather, they are kept the longer in ward. When quite recovered, the ewes, with their lambs, are put into a field of new grass, where the milk will flush upon the ewes, much to the advantage of the lambs.

It is generally a troublesome matter to drive ewes with young lambs to any distance to a field, the ewes turning round upon and bewildering the lambs. The dog irritates the ewes more than assists the shepherd in this task. A plan often adopted is to lead the flock, when small, instead of driving it, by carrying a single lamb, belonging to an old ewe, by the fore-legs, with its head between the legs —which is the safest way of carrying a lamb—and walking slowly with it before the ewe; she will follow bleating close at the shepherd's heels, while the rest of the ewes will follow her. If the distance to the field is considerable, the decoy lamb should be set down to suck and rest, and another taken for the purpose. When the number of ewes and lambs is considerable, they will have to be driven, and that quietly, and with plenty of time given them.

Mothering Lambs.—When ewes and lambs are turned out to pasture, or out of the lambing-fold, the shepherd ought for the first ten days to see, at least twice a-day, that every lamb is with its own mother, and especially in the case of twins, to see that they are both having regular access to the right ewe. Distinctive marks with paint on ewes and lambs are helpful in this work of *mothering*.

Risk of Over-forcing Lambs.—In putting ewes and very young lambs on to luxuriant grass, care is necessary to see that the lambs are not too hard forced with milk. Mr George Brown, Watten Mains, Caithness, says: "If the pasture is rich and the ewes very full of milk, there will be danger of lambs dying from inflammation and apoplexy. Change of diet may stop this fell epidemic, for such it may become, especially if there is an east wind at the time. Scores of the strongest lambs have been lost in a few days in this way. Careful change and moderation in feeding are the best preventive treatment."

Protecting Lambs from Foxes.—Foxes are apt to snatch away young lambs at night, even close to a lambing-house. An effectual preventive to their depredations has been found in setting a sheep-net (fig. 75, vol. i. p. 172) in front of the lambing-houses, leaving sufficient space for a few ewes with their lambs making their lair within the net. When thus guarded, with a lantern burning outside, the foxes become apprehensive of a snare, while the lantern serves the useful part of affording ample light to the shepherd to see his valuable charge. The expedient of net and lantern was tried after several lambs had been destroyed in successive years by foxes, and a lamb was never afterwards lost in this way. A fox will seldom meddle with a lamb above a month old.

It is easy to distinguish between an attack by a fox and by a dog. The fox seizes the lamb by the neck behind the head, to throw it over his shoulder, and, if he is scared at the moment, distinct bite-holes of the teeth will be found on each side of the neck; whereas a dog seizes any part of the body, and worries by

tearing the under part of the neck. The fox, if not disturbed, carries off his prey bodily—he does not take time to eat it on the spot; whilst the dog leaves behind him what he does not eat. Some ewes will fight off either dog or fox, and stoutly protect a single lamb; whilst others are so afraid, that they know not whither to flee for refuge. After an attack, the bleating of the ewe in search of her lamb—an unusual occurrence at night—will acquaint the shepherd of the disaster that has happened.

Unkindly Mothers.—Much trouble is imposed upon shepherds when ewes will not take their own lambs. In every case of a ewe refusing to let her own lamb suck, the shepherd should particularly examine the state of the udder, and ascertain the cause of uneasiness. If it be inflammation, or simply hardness, remedial measures must be used to restore the udder to its natural state. If the udder be well, the ewe must be put under discipline.

The discipline consists of putting her into the shed, and confining her to a spot by a short string tied above the fetlock of one of her fore-legs, and fastened to anything. As she endeavours to avoid her lamb, the string pulls her foot off the ground, and while her attention is taken up struggling with the string, the lamb seizes the teat and sucks in the meantime; the stratagem, often repeated, makes her take with the lamb. It is surprising how soon the lamb learns to steal a suck from its mother; if it cannot approach her by the flank, it will seize the teat from between the hind-legs. When a ewe will allow but one of her twins to suck her, she should be held till both do it, and in a short time she will yield to both.

Introducing a Strange Lamb to a Ewe.—It is not surprising that a ewe should refuse to take the lamb of another; and yet, when a lamb is left an orphan, or happens to be a supernumerary, it is necessary to *mother* it upon another ewe, or to bring it up by hand as a pet; the former if at all possible. When a gimmer that has little milk has twins at a time when a ewe that has plenty of milk produces a single lamb, it is for the benefit of the gimmer and one of her lambs that the ewe should bring up two lambs. The fostering is easily accomplished while the lambs are still wet, and the two are placed before the ewe at the same time. But in the case of a ewe that does not die till two or three days after she has lambed, it will be difficult to make another ewe that lambs a single lamb, at the time of the death of the ewe, take the older lamb along with her own.

The usual plan is, to rub the body of the older lamb with the new-dropped one before the ewe had recognised her own lamb, and to place both before her at the same time. She may then take both without scruple; but the probability is, she will reject the older one. If so, she may be put into a dark corner of the shed, and confined by a board placed across the corner, giving her room only to rise up and lie down, and to eat, but not to turn round upon the stranger lamb to box it. Meanwhile, being strong, and rubbing itself against her wool, and sucking her against her inclination, the lamb will acquire the odour of her own lamb, and ingratiate itself in her favour. If she persist in refusing the lamb for some days, the discipline of tying the leg must be resorted to in the confined cell until she yield.

Another troublesome case is, when the lamb dies at birth and the ewe has plenty of milk, while another ewe with twins is unable to support them. The expedient is, to let the ewe smell her own new-born dead lamb, and then to strip the skin off it while wet, and sew it upon the body of one of the twin lambs, and present the foster-lamb to her, which she may accept when she has been sucked by it. But it is possible that the dark corner will have to be used before she gives a cordial reception to the foster-lamb. Should all these expedients fail to *mother* the lambs upon the ewes—and they *may* all fail, though with a skilful shepherd they rarely do—the lambs should be taken away and brought up as *pets* on cow's milk.

"Stocks" for Refractory Ewes.—Of the various forms of discipline administered to ewes that are unwilling to admit foster-lambs, placing in "the stocks" is perhaps the most irksome. In bad cases it is usually the most speedily effective. The stocks are formed in this

way: Two small posts, such as hurdle stakes, are driven firmly into the ground about six inches apart. The head of the ewe is passed through between these posts, and a thong or shackle is passed over their tops, so as to keep the posts sufficiently close to hold the ewe by the neck. A third stake is passed horizontally under the ewe's belly, and supported at the two ends on the bottom bars of two hurdles placed on either side of the ewe, but far enough from her to enable the lamb to approach its foster-mother. In this manner the ewe is most effectually brought into subjection, for she can neither run away nor lie down, which many foster-mothers would do at first in order to prevent a strange lamb from sucking. A very short experience of this form of discipline will usually be sufficient to induce the ewe to freely accept the lamb.

Changing Ewes and Lambs.—Mr George Brown, Watten Mains, Caithness, considers that there need really be little difficulty in making a ewe take to any lamb. "When a ewe becomes careless of one of her lambs," he says, "a good plan is to lift them both away from her, and place them in a box or barrel by the side of the fence, and suckle them three or four times a-day. They thus soon become so identical in smell that the ewe is willing to admit them both. Another plan is to rub both lambs with *salt and water*, so as to make them alike in smell.

"When gimmers (or shearlings) and older ewes are lambing at the same time, we often change lambs, always putting a single lamb with the gimmer. The best plan, when a gimmer lambs twins and an older ewe a single, is to lift the twins from the former to the head of the latter, and give the gimmer the single lamb. If neither be allowed to smell her own lambs, she will readily enough adopt the other. I have seen a hundred lambs so changed in one season without any great trouble."

The Newly-born Lamb.—It is wonderful how quickly the newly-born lamb attains vitality and vigour enough to move about and seek for its mother's udder. As a rule, the lamb needs little attention after birth; but it is of course desirable that the shepherd should be at hand to see that matters progress satisfactorily. The first duty of the shepherd after the lamb is born, says Professor Wrightson, is to clear its mouth of mucus, and see it draw its first breath. Previous to birth the *fœtus* receives oxygen through the mother. It is her lungs which vivify its blood, and her digestive system which prepares its nourishment. But with the breaking of the *umbilical* cord comes the necessity for air, and after a convulsive movement of the diaphragm and intercostal muscles the young creature gasps, and generally utters its first cry. Whether the almost universal practice of shepherds, of blowing into the lamb's mouth, facilitates this action, is not certain; but it is probable that this simple expedient excites the slumbering vitality, and causes the necessary muscular contraction. A slap with the flat of the hand across the buttocks will also often cause a lamb to draw its first breath, when animation appears to be suspended for a few seconds after birth.[1]

Reviving Weak Lambs.—Various devices are resorted to in order to revive weakly lambs. "Those naturally puny need to be kept in good shelter for some days, and if their dams have plenty of milk they will soon get strong. The usual trouble with young lambs is cold and hunger. A lamb so chilled that the thumb and finger held on opposite sides of the chest can scarcely detect the heart-beats, can be restored by an immediate plunge into blood-warm water. But this should be resorted to only in desperate cases, for the water is likely to obliterate the scent, by which alone the ewe recognises her offspring. For the same reason it is equally dangerous to wrap the lamb in malodorous cloths, and allow it to lie before a fire. It will probably be a long time in recovering, and the chances are that the natural scent will be lost; then there will be trouble in establishing relations again between it and the mother. Then, too, the lamb will most likely have to be fed on cow's milk, which is the greatest evil that could happen.

"If at all possible the lamb should never be removed from its mother. Carry out soft woollen wraps, well warmed, and wrap it up, letting the head remain out where the ewe can smell and lick it when disposed; she will thus keep up her ac-

[1] *Live Stock Jour.*, 1889, 114.

quaintance with it. The sooner some warm milk is given it the better. The creature may be so chilled that it cannot suck, yet it may not be advisable to carry it to the fire. Catch the ewe gently with the crook; lay her on her left side, yourself being squatted at her back; lay the lamb on its right side; with the thumb and finger of the left hand hold the jaws apart, and milk a few drops into the mouth. Still holding the jaws apart, rub the throat with a downward stroke, and it will swallow. If it cannot swallow, it will probably have to be carried to the kitchen. But try every expedient before carrying a lamb away from the sight and touch of its mother. Never give a young lamb more than a tablespoonful of milk at a time, and a teaspoonful every ten minutes will be more effective still, when life is but a spark."[1]

Stimulants for Weak Lambs.—When a lamb has become so prostrate as to necessitate removal from the mother, it should not only be placed upon a woollen cloth near a moderate fire, but have a little stimulant administered as well. Some experienced shepherds recommend from a half to a whole teaspoonful of gin or whisky in a little warm water, sweetened with moist sugar; a very little of its mother's milk—or the milk of another newly lambed ewe, if its own mother is not alive—should also be given without delay. The ewe should be milked into a small jug or cup, and the milk at once conveyed to the lamb, which may be fed by a teaspoon. If the milk gets cold before being given to the lamb, it should be heated to the normal temperature by the addition of a few drops of hot water, or, better still, by a clean hot piece of iron inserted into it.

Pet Lambs.—Pet lambs consist of orphans or supernumeraries, and in either condition are deserted creatures which would die were they not reared by hand. When ewes die, it may be difficult to avoid having pets, on account of the improbability of ewes lambing single lambs just in time to receive those which have become orphans. Pet lambs are brought up on cow's milk, which they receive warm from the cow at each milking, and as much as they can drink. Cow's milk is not so good for lambs as their mothers' milk, though they thrive upon it.

In the intervals of meals, in bad weather, pet lambs are kept under cover, but in good weather they are put into a grass paddock during the day, and under shelter at night until the nights become warm. They are fed by hand with as much milk as each can drink. They are first taught to drink with the finger, and as soon as they can hold the finger steady in the mouth, an india-rubber teat, about 3 inches in length, is used as a substitute, through which they will easily drink their allowance of milk. The lambs soon become attached to persons who feed them. The ancient Greeks had a notion that if lambs were fed on ivy-leaves for 7 days, they would ever continue healthy.

Cow's Milk for Lambs.—Caution is required in beginning a young lamb upon cow's milk. Much difference of opinion would seem to have long existed as to the influence of cow's milk upon young lambs — some contending that it is dangerous, and others affirming that it may be used with safety. The milk of a newly calved cow is said by some high authorities to be especially risky, but others equally well entitled to confidence assert exactly the reverse. Be all this as it may, the fact is, that every year large numbers of lambs are reared upon the milk of cows newly calved and long calved; and it is well known that the pretty high rate of mortality amongst these "pet" lambs is due to irregular and excessive feeding. With intelligent care at the outset, giving small allowances and often, and taking care to have the milk at the natural temperature, and afterwards feeding in moderation and at regular intervals, the youngster will be found to thrive well upon the cow's milk.

Heating Milk for Lambs.—It is not considered a good plan to heat milk for lambs by the addition of any appreciable quantity of water. The milk should be given immediately it is drawn from the cow. But if it has been allowed to cool it may be raised to its natural heat by being placed in a cup upon the kitchen range for a moment, or by a clean hot iron being inserted in the milk.

Scour in Lambs.—Cow's milk, given too freely, is liable to cause scour or diar-

[1] *Prac. of Sheep Farm.*, 82.

rhœa in lambs. Especially when very young, lambs are subject to various forms of diarrhœa, arising from various causes, some of which are not easily removed. "Scout" is a fatal form of diarrhœa amongst lambs about two or three days old. As soon as symptoms of this ailment are seen, the ewes and lambs should be removed to a fresh lair or shed, and, as a rule, this change of scene will check the disease. A teaspoonful of castor-oil is often given with good effect to lambs suffering from diarrhœa.

Carrying Lambs. — Young lambs should be handled as little as possible. When they have to be carried, this should be done by the two fore-legs. Never seize or carry a lamb by the body.

Cleaning Ewes' Udders.—Any loose wool should always be removed from the udders of ewes at lambing, so as to prevent the lamb from swallowing pieces of wool, and forming hair-balls in the stomach. These balls often prove fatal to the lambs, and they are sometimes formed by lambs on bare and dirty pasture where pieces of wool are lying about.

Catching Ewes.—Great care should be exercised in catching ewes at all times, more especially, of course, when they are near the lambing-time. It is a common practice with shepherds when they wish to catch a ewe to give a weakly twin lamb a suck, or to examine the state of her udder, to stoop down and run in upon her from behind and seize her by a hind-leg. This is a safe mode of catching a ewe when dexterously done; but when he fails, she will start and run off, and alarm the other ewes beside her—and every alarm to a ewe, whether lambed or about to lamb, is injurious, and at any rate cannot do any good.

Shepherd's Crook.—A *crook* catches the leg quietly and securely. It consists of a round rod of iron, bent in the form shown in fig. 247, terminating at one end in a knob, and at the other end in a socket, which receives and is fixed to a wooden helve, 5 or 6 feet long, according to fancy. The hind-leg is seized from behind the sheep; and as its small bone just fills the narrowest part of the crook, the leg cannot get loose backwards, and remains in the roomy loop of the crook until the shepherd has caught hold of the sheep, and allows its foot to slip through the loop. Some caution is required in using the crook, for should the sheep give a sudden start forward to get away the moment it feels the crook touch its leg, it may forcibly draw the leg through the narrow part, and strike the fore edge of the bone with such violence against the bend of the loop as to cause the animal considerable pain, and even occasion lameness for some days. On quietly hooking the leg from behind the ewe, the crook should be quickly drawn towards you, so as to bring the bend of the loop against the leg as high up as the hock, and lift the foot off the ground, before the sheep is almost aware of the movement; and being thus secured at once, her struggles will cease the moment the hand seizes the leg. The crook is placed in the figure to catch the off hind-leg.

Fig. 247.—*Shepherd's Crook.* *a* Narrowest part of crook.

LAMBING PERIOD—DETAILS OF MANAGEMENT.

It may at first thought seem curious that within the narrrow limits of the British Isles there should be such a length of time as there is between the dates of lambing in the earliest and the latest districts. The lambing period in this country now actually extends over six months, beginning with Dorset sheep in the extreme south of England in November, and ending with mountain sheep in the north of Scotland in the month of May. Lambing, therefore, stretches into three seasons of the year, yet it is in a special sense associated with spring, and is conveniently dealt with in this part of *The Book of the Farm.*

In detailing the different systems of management, the prevailing dates for lambing in the various districts will be noted. Climate is, of course, the chief element in determining the time of lamb-

ing, as it is desirable that there should be a plentiful supply of green food for the ewes while nourishing their young with milk. In certain cases a more highly artificial system of rearing or forcing is pursued, with the object of providing early lambs for the meat market.

Early Market Lambs.

Dorset Flocks.—The fattening of lambs for slaughter when a few months old is now pursued extensively in various parts of the country. This practice has been so skilfully carried on with Dorset sheep in the extreme south of England, that in some cases two crops of lambs are obtained in one year from the same ewes. The ewes of this breed are very prolific, and have come to possess the characteristic of turning very early to the ram. For early market lambs the Dorset ewes are usually crossed with a Down or cross-bred ram, and by feeding the ewes freely upon trifolium and cut swedes or mangels—with a run on fresh dry pasture, and perhaps half a pint each of beans daily—they are brought to take the ram as early as May and June. When the rams are withdrawn, the ewes are changed to a dry pasture with a fold of tares or other similar forage crop, and are kept in moderate condition. The ewes walk a good deal daily, and this healthy exercise has a favourable influence on the crop of lambs.

These ewes lamb in November and December. In average seasons only the weakest of the lambs need to be taken into the shed, the climate being so mild that even in the middle of winter the young lambs thrive admirably by the side of their mothers in the open fields. When the weather is wet and stormy, the ewes and lambs have to be housed or brought into some exceptional shelter till the worst of the storm is past, but no unnecessary pampering is practised.

Preparation is made for the ewes with the early lambs by serving rye-grass on portions of the wheat stubble. This fresh young grass is peculiarly suitable for newly lambed ewes, and upon this and the run of the stubble at night, and a "bite" of young clover by day, they are able to nourish their lambs bountifully. Castration is delayed till the lambs are about a month old, it being considered that lambs left entire for a month are more fleshy when matured than lambs castrated when ten days' old, which latter plan is pursued by many.

Fattening Ewe and Lamb together.—About the end of the first month the ewes and lambs are put upon roots, and liberal fare is provided, as the intention is most likely to fatten both the ewes and the lambs at the same time. The system of feeding now pursued is thus described by Mr John A. Clark:—

"The roots are cut and given in troughs, and the lambs feed in advance of, and separate from, the ewes—a lamb-gate being provided for the purpose, having a space between the bars to allow lambs to pass, without being wide enough for the ewes. As soon as it is light in the morning, the shepherd gives hay to both lambs and ewes, and then fills the troughs with cut roots, passing the lambs' portion twice through the cutter, reducing the slices into bits the size of dice. Next he gives oilcake and peas in covered troughs, the allowance being as much as they will eat. To prevent waste the oilcake is broken fine—the size of horse-beans—so that the lambs do not take up large pieces and drop them beside the troughs. To induce the young animals to eat cake and peas, it is sometimes necessary to mix a portion of common salt. The ewes next receive their portion of oilcake, *without* peas, beginning with ¼ lb. per day—half in the morning, half before the bait of roots at night. After two or three weeks of this food, the cake is gradually increased up to 1 lb. each per day; and towards the end of the fattening process half a pint of beans is added. This renders the flesh more firm; the great objection to the ewes being fattened while suckling being that they are mostly deficient in firmness and quality of meat.

"Hay or hay-chaff also is given to the lambs twice a-day; but after eight or nine weeks old they have it three times a-day—the last feeding being not later than three o'clock, as the hay not eaten will be spoiled in case of rain. The portions of hay, after having been picked over by the lambs, go to their mothers. The lambs are ready for the butcher at ten

or eleven weeks old—that is, in February and March."[1]

Lamb for Christmas Dinner.—In some instances in Dorset and the Isle of Wight lambs are dropped in September, and fattened for sale by Christmas. With this practice the system of management has to be still more artificial and forcing. This highly artificial system is no doubt remunerative to the enterprising farmers who pursue it. It is not to be assumed, however, that the rearing of fat lambs for Christmas, or even for Easter, would be either practicable or profitable in other parts of the country. "In Devon and Wilts there are numerous sunny glades and warm sheltered vales, where, assisted by the hot vapours of the Gulf Stream wafted across the Atlantic by the south-western breezes, the grass is ever green." Thus the flock-owners in these favoured parts have advantages not enjoyed to the same extent in other districts.

Hampshire Customs.

The practice of rearing and fattening early lambs has been more extensively and successfully developed with flocks of Hampshire Downs than with any other variety of sheep outside the domain of these wonderful Dorset flocks. The Hampshire Down has been skilfully cultivated with this end in view, and the whole system of farming in Hampshire has, to a large extent, been arranged to promote the rapid production of mutton.

Lambing begins with the new year in Hampshire flocks, and at this season great care has to be exercised in protecting the young lambs from stormy weather when it occurs, as it of course often does. The water-meadows in the chalk districts of the south-west of England are turned to good purpose in furnishing an early supply of fresh grass for ewes, and in addition to these, a great deal of other succulent green food, such as roots, cabbage, thousand-headed kale, rape, rye, vetches, trifolium, &c., has to be provided for the ewes and lambs in winter and spring. Where there is a considerable stretch of good water-meadows, there is less necessity for other succulent food; but in dry lands where water-meadows cannot be formed, great store is placed upon the forage crops.

It is undesirable to force ewes into high condition before lambing; but it is an essential feature in the management of early lambing flocks that as soon as the lambs are dropped the ewes should be fed liberally with succulent milk-producing food. Liberal feeding has more to do with the progress of young lambs than the mildness of the weather. It is, indeed, wonderful how even very young lambs will withstand cold and wet weather if only their mothers have plenty of good milk for them. They are, of course, all the better of shelter, and ought to have it; but above everything else, see that they are well nourished with milk. And the surest way of providing this is to feed the ewes liberally after lambing.

Lambing on the Arable Farms.—For this early lambing on the arable farms of the south-west of England, mild as the climate is, it is desirable to have a well-arranged and ample lambing yard or pen.

"The forward ewes," says Professor Wrightson, "should be brought into the pen every night and lie upon the straw. A good-sized heap of swedes should also have been provided, and hay racks or cribs should be placed around, so that the animals may receive a foddering when they come into shelter at about four o'clock in the afternoon. During the height of the lambing, the shepherd remains night and day with his flock, and provided with a good lantern, he makes periodical visits, carefully looking at every ewe. As soon as a lamb is born, it and its dam should be removed into one of the coops or cells, as already mentioned, there to remain for three or four days, until the lamb is able to follow its mother without difficulty, and until the two thoroughly know each other. When this is judged to be accomplished, the cell is vacated for other occupants, and the ewe and her lamb or lambs are transferred to one of the larger divisions of the pen.

"As lambing proceeds, the various lots of ewes are classified and separated, as follows:—

1. A yard of ewes heavy in lamb.
2. " " with single lambs.
3. " " with twins.
4. " " and very young lambs.

[1] *Jour. Royal Agric. Soc. Eng.*, 1878, 520.

"The older lambs, with their dams, are, when from four to seven days old, allowed to go out upon the turnips, and it is interesting to watch these young creatures learning to fend for themselves, and imitating their mothers in their eating, choosing the softer parts of the turnips, nibbling at the rape or turnip greens, or sorting out the choicer portions of the hay.

The Lambs' Corner.—"Lambs ought to be provided with a corner for themselves at an early age. A few hurdles should be placed around so as to include some small troughs in which is placed a mixture of split peas, bruised oats, and finely ground cake. Admittance is given to this enclosure by means of lamb-hurdles, which, while allowing of the ingress of the lambs, is a bar to the larger-sized ewes."[1]

Lord Northbrook's Flock.—The fine flock of Hampshires kept at Stratton, Micheldever, by Lord Northbrook, is managed similarly to the other leading Hampshire flocks. His lordship's agent, Mr T. Stirton, says: "Lambing takes place, as a rule, from the middle of January to middle of February. Ram breeders commence on the 1st of January. Generally speaking, the ewes get plenty of hay or sainfoin with a *limited supply of turnips* before lambing, and plenty of roots and hay afterwards. Ram breeders use artificial food, such as malt-dust, cake, &c. The ewes are always folded on arable land, and the roots are not cut for them. After the roots are finished, rye and winter barley follow. As a rule, the lambs are weaned about the first week in May, when the lambs have field-grass, followed by vetches during the summer —usually a fold of each a-day—or sainfoin. If not sold at the summer fairs, or sold fat at the auction sales, they then get sainfoin, rape, and turnips, till the autumn fairs, with or without cake, according to the views of the owner. The ewes live behind the lambs, for the latter have large folds. Ram breeders give their lambs at least two to three folds of different kinds of food each day, with various mixtures of artificial food. The green foods are vetches, early rape, and sainfoin."

[1] *Live Stock Jour.*, 1888, 65.

The plan of having one lambing-yard near the homestead, once general, is now in most cases supplanted by temporary lambing-pens formed at some convenient spot on the fields, near the supplies of green food, and where the manure is most required.

Treatment of Ewes and Lambs.—As a rule, in fine weather the ewes go out from the pens on to the turnip-break when the lambs are two or three days old, but in some exceptional cases they are kept in shelter with their young lambs for two or three weeks. The ewes and lambs are usually kept on turnips and hay till the water-meadows are ready to receive them, perhaps about the first of April, and then they go on to the water-meadows by day, and are folded overnight on Italian rye-grass, rye, winter barley, winter oats, or trifolium, sown for the purpose—the tup and wether lambs intended to be forced being admitted in front of the hurdles to receive a little cake or corn. Where there are no water-meadows there is usually a preserved portion of clover, which forms a most useful adjunct to the turnips and forage crops.

Frequent changes of ground and food are a leading principle in Hampshire flock management, and no doubt this contributes largely to the success of the system.

Forcing Young Lambs.—For the first two, three, or four weeks the lambs subsist upon their mothers' milk, but even before they are a fortnight old they will be seen to nibble at the finer portions of the food being consumed by the ewes. The forcing of lambs may be begun in the third week, and if the object is to rear precocious ram lambs or fatten wether lambs at as early an age as possible, a separate enclosure of hurdles in advance of the ewe-fold should be formed for the lambs. The lambs get access to this enclosure through an opening in the ordinary hurdles—an opening not large enough to admit ewes—or by what is called a *lamb-hurdle*. In this lamb-fold the young lambs will pick at the fresh food before it has been spoiled by the ewes running over it, and in troughs they should receive cut roots—put twice through the cutter, so as to reduce them to small pieces—and just as much of the

bruised cake and grain as they will readily consume, with a very small quantity of fresh hay. The mixtures and quantities given to lambs vary on different farms. As to quantity, the rule should be—if the lambs are to be forced—to give them as much in two or three meals per day as they will eat up at the time. A mixture of linseed-oil and peas gives excellent results. Another very good mixture may be made of equal portions of finely ground linseed and decorticated cotton-cake, bean-meal, and palm-nut meal, given perhaps with fine hay-chaff. It is not likely the lambs will eat much more than about two ounces per day of this mixture till they are weaned, after which the quantity may be doubled.

Lamb-hurdles.—The lamb-hurdle or lamb-creep, contrived to let the lambs run forward and hold back the ewes, is an important institution where breeding flocks are kept on arable land. "The lamb-hurdle," says Professor Wrightson, "is in constant requisition throughout the spring, and by its means the lambs are able to run forward and crop the choicest herbage before it is soiled or trampled by the older sheep. The best creeps are adjustable to the size of the lambs, and the upright bars through which the young animals pass are round and smooth, and revolve easily upon a central axis of iron. They are also furnished with a similar roller, which forms the top of the creep, so that the lamb passes through without rubbing the wool. The opening is hinged inwards, but is rigid when pushed outwards, and this is done to allow of lambs running quickly back into the fold if frightened, but at the same time to prevent the ewes from passing outside the fold." [1]

Various English Methods. — The foregoing details, which relate chiefly to Hampshire flocks, embrace the outstanding features of the systems of management which prevail wherever early lambing is pursued—that is, lambing in January, February, and the beginning of March. The amount and character of shelter and green food provided for the ewes and lambs vary with the locality, climate, class of sheep, purposes in view, and date of lambing. Wherever the ewes are timed to lamb before the middle of March, ample shelter and green food must be furnished; for without comfort and plenty of nourishment for the young lambs, early lambing cannot possibly result in success.

The systems of management in some typical English flocks are described in Division I., pages 194 to 201.

Summersbury Southdowns. — Mr Edwin Ellis, Summersbury, Guildford, Surrey, whose fine flock of Southdowns has taken a high position in the show-yard, writes:—

"For several years I have been desirous that my lambs (Southdown) should fall in January and February, instead of from the middle of February till the beginning of April, but I have as yet been unable to obtain this result. It is true that by forcing treatment and very high feeding a few ewes would come into season in August, possibly even at the latter end of July; but this would be very expensive work at a period when we expect the flock to be kept at the smallest possible outlay. In the present year (1888), although the rams were put out on the 16th August, the first ewe was served on the 27th, and it was not till several weeks after this that any considerable numbers were tupped.

"Lambing, therefore, begins with us about the beginning of February, and we generally get half-through by the end of the month; and by the end of March the season may be said to have finished, although a few ewes will be still later than this.

Feeding of Ewes.—"When the ewes have gone half their time, we take care that they shall be well fed, having a little hay, and sometimes a few oats, but no roots if we can avoid it. After lambing we feed very liberally—good hay, swedes and swede-*tops*, if there are any, and sometimes a few mangels as well. I consider mangels better even than swedes for milk. The ewes are driven into a fold if the weather is bad, otherwise they do better in the open field.

Treatment of the Lambs.—"Directly the lambs begin to feed, they have a pen into which they can run, and sliced swedes, corn, and cake are at their disposal. If we get a large proportion of twins, a separate flock is made, and the

[1] *Live Stock Jour.*, 1888, 114.

mothers have some corn in addition to their other food. I have generally weaned when the lambs are about 12 or 14 weeks old, but I think it might be done earlier with advantage.

"When the lambs are taken away, careful attention should be given to the ewes' udders for the next few days, otherwise great pain, and possibly inflammation, may be caused by the milk. My lambs are kept on tares, trifolium, thousand-headed kale, and clover, each in their turn; and if we find it practicable to give a change of food to the ram lambs, it is beneficial. Indeed the greater variety the better.

"As for the ewes, directly the wool is off they run the commons around us, and come on to the meadows when the crop of hay has been harvested.

"Flushing" Ewes.—"I have always had a good number of twin lambs, consequent, as I believe, on 'flushing' the ewes with plenty of green food just before they come into season. The young ewes have generally one lamb, but the old ewe flock with me generally bring three lambs to two ewes, and sometimes even more than this."

Suffolk Flocks.

With the leading flocks of Suffolk sheep, which have been greatly improved in recent years, the ewes and lambs are managed with much care and intelligence. In his Prize Report to the *Farming World* in 1888, George Last, shepherd to Mr S. R. Sherwood, Hazelwood, Suffolk, says:—

"The farm consists of marshes and rough pasture and arable land, and is about two miles and a half from the sea—a cold, bleak place, but most of it good light land, with about three or four fields black and poor land even for breeding ewes.

"My flock consists of 300 Suffolk ewes, bought from the best breed of the Suffolks. Six ram lambs were used of the same breed as the ewes on October 11. One ram was put to 50 of the best ewes, and five to the other 250, which is fifty each for a ram. The 50 ewes and one ram are put on the marshes night and day for three weeks, and the 250 on the marshes during the day, and folded on coleworts at night. The rams lived as the ewes did, and were drawn from the ewes the last week in December.

Lambs Dropped.—"The ewes began to lamb on 6th March, and ended 21st of May. As for the number of lambs dropped, I do not keep strict account until I tail them, which is done when they are about a fortnight or three weeks old; and I have tailed this season 454. I have about 170 twins, 25 triplets, and the rest singles, with 3 barren ewes. I had 443 lambs living on May 29th. One lamb has died since I tailed them, with a ball of wool in its stomach, and another with sand; the others died from what we call *scoley*, caused by the cold severe weather, such as I never before experienced. We had snowstorm, and hailstorm, and frost at night all through March and part of April, and that is the cause of the lambs being scoley and stiff-jointed. They then linger and die. I should think I have lost from 40 to 50 in that way, though I had plenty of shelter.

Lambing-yard.—"My sheep-yard was made on the open common with hurdles first, then whin fagots, then straw hurdle-pens round inside and outside to the number of about 70 pens, and then thatched with straw. I keep them in the pens two or three days, then turn them on the field under the bank and battens made with whin fagots on purpose.

Feeding of Ewes.—"The general feeding of the ewes consists of maiden leys, marshes, and coleworts for the tupping season. Then follow on with white turnips and a good bait of malt-combs and chaff every morning, and a run on the whin common every day; and about a month before lambing a bushel of best oilcake to two bushels a-day mixed with the chaff and malt-combs, and from half a load to a load of mangels per day. When the ewes refuse the chaff, increase the cake to three or four bushels, and the mangels to two and three loads per day.

Feeding of Lambs.—"About the middle of April we begin to bait the lambs. I shut them from the ewes about an hour every morning for the bait, then let the lambs run forward on the clover leys for a time; the ewes then clean out what bait the lambs leave, and which is

a good deal at first, but the lambs soon get hold of it and leave the ewes very little.

Losses of Lambs.—"I have lost nine ewes from the following causes: One in January from scour and inflammation; two in February from ulcer-sores; four in March—two broken down from weight, one from dead lamb's putrefaction, one wasted by ulcers; and two in April—one casted or awal'd, and one choked with mangels. There are now 443 lambs alive, reared from the 300 ewes."[1]

Shropshire Flocks.

For the following description of the prevailing system pursued during the entire year in Shropshire flocks, we are indebted to Mr Alfred Mansell, College Hill, Shrewsbury—the round of the year being commenced when the rams are admitted amongst the ewes:—

The ewes are put to the ram early in September, so as to drop their lambs early in February or March; but in high cold districts the lambs, as a rule, are all dropped in March and early in April.

Flushing the ewes is considered advisable at the tupping period, as the ewes go faster to the ram, and are generally more prolific. If so treated and for this purpose, they are put on a fresh pasture, say second year's seeds, or a permanent pasture which has been purposely saved.

To ease the rams sometimes *a teaser* is used, and the ewes as they come on are taken to the ram. This is quite necessary in the case of a very fat ram, or where it is wished to serve a larger number of ewes with a certain ram than is usually the case.

If any *show ewes* have been added to the flock, they should be treated precisely in the same way, but perhaps may be put to the ram a little earlier, as they are apt to turn several times before holding to the rams. Still, with care and patience, they can generally be got to breed.

Ram Lambs.—At the latter end of the season, should any of the ewes have turned several times, and this will probably be the case with a few of the older ewes, a ram lamb should be tried; but, as a rule, I should not commend this practice, as it is difficult for even a good judge to select a good lamb, or, in fact, any immature animal.

The *ram selected* for use should be as large as possible, combined with masculine character, perfect type, and high quality; and as a rule the size should be looked for on the side of the dam, as it is next to impossible to procure a male perfect in all the essential points, and yet with sufficient size. Rams generally will serve from thirty to fifty ewes satisfactorily, and in many cases this number is greatly exceeded. But a ram should seldom be used largely until his second year as a sire, when the breeder has had a chance of seeing his produce and of judging what they are likely to grow into.

After the ewes have all been served they run together, and for another month or so should be kept in as thriving a state as possible. They then go to old seeds or pasture and get a daily allowance (not too large) of roots and hay; the latter loose on the fields is best, as the ewes are apt to get crushed if crowded at racks.

Preparation for Lambing.—Some breeders, a short time before lambing, give the ewes boiled linseed, crushed oats, and bran mixed with pulp and cut stuff. This is a practice much to be commended, as it strengthens the ewes and greatly assists a safe and easy parturition.

As soon as the *lambing season* approaches (end of January or early in February) the ewes are folded at night. When the lambs are a few days old they go on to the seeds which have been kept up during the winter, and if the season has been moderately favourable these are usually very fresh, and a good pasture for promoting the secretion of milk. Only the ewes with twin lambs should get any assistance, as the ewes with single lambs if corn-fed are apt to get too fat and doubtful breeders. A mixture of beans, malt-dust, linseed-cake, and bran, is a capital food to sustain the ewe and increase the flow of milk.

The shepherd should, as far as possible, be encouraged to keep up the returns from the sheep by means of a bounty on each lamb alive at weaning-time (June), and also by giving him a further interest

[1] *Farming World*, 1888, 526.

in another way in the wellbeing of the flock.

Castration in ram breeders' flocks is not a general practice, and the process of selection is left until the winter, when the inferior rams are fed and sold to the butcher. In the case of ordinary flocks they are *castrated* as lambs and sold fat the following spring.

Shearing the lambs, which takes place about the last week in June, is considered to have a good effect in securing greater immunity from the fly in summer; also in preventing the clinging of the soil to the belly of the sheep when on turnips.

Weaning the lambs takes place in May or early in June. For this a good pasture is selected, as with good treatment they do not feel the change so much. No strong artificial food should be given at first, but a few common turnips may be thrown about on the ground to teach them to eat turnips. Following this, rape or cabbages are given, and as the harvest-fields are cleared the young seeds are made use of. This would carry the lamb till the end of September or so, when they are folded on common turnips till about Christmas, and then on swedes. Linseed-cakes, oats, and bran, commencing at ¼ lb. each per day, and gradually increasing, is the artificial food at this period.

As January and February come in, the *cull rams* are ready for the knife, and by the end of the latter month most of these have been despatched.

The rams intended for show and sale and the *shearling ewes* are kept on the turnips a little longer, or until the land is wanted for barley-sowing. The rams intended for show are housed early in April and shorn, but the majority are not housed until May. The rams then get mangels, hay, and a small allowance of corn, and as much green food as possible. This latter is a most necessary food. Mellowing the mangels by exposure to the sun is a good practice, as it renders them less liable to develop the water complaint amongst the rams.

The ewes after the lambs are taken from them are kept on the barest pastures, as they are apt to get gross and fat and non-breeders if they are allowed a good pasture during the summer months. Indeed many breeders, through a little carelessness on this point, annually spoil several of their best ewes.

The average *number of lambs* is 150 to 175 per cent. In small flocks it has often been much more, but, speaking generally, a lamb and half to three-quarters for each ewe is about the average.

Dipping the lambs once or even twice is very desirable, and for this purpose a non-poisonous dip is best.

To prevent *husk* or *hoose* in lambs, a most fatal complaint in the autumn, it is an excellent plan to drench the lambs either with one of the well-known patent remedies, or with the following, which costs less, and is to all intents and purposes as good: ⅛ oz. asafœtida, ⅛ oz. turpentine, ⅜ oz. linseed-oil, given in half a gill of milk or thin gruel, two days consecutively.

As a preventive against *foot-rot* it is a good plan to periodically, say two or three times a-year, carefully pare all the sheep's feet, and walk them through a trough containing a disinfecting solution (composed as described on page 198, vol. i.), after which they should be folded on a hard road or dry yard for a few hours.

Mr Carrington on the Care of Ewes and Lambs. — The late Mr W. T. Carrington, in describing the general management of sheep on light-land arable farms in England, said: "The time of putting the ram with the ewes varies with the locality, and the prospect of early spring food. In the south of England, August and September are usual months. In the midlands, October; and in the north, November. On those farms where rams are bred for annual sale, they are usually dropped early, so as to give them a good start.

Condition of Ewes at Mating-time. —"It is better that ewes going to the ram should be, though not fat, in an improving condition, a supply of succulent food at this period having also a favourable influence on the number of lambs dropped; therefore many farmers put their ewes on rape.

Ewes in Winter.—"In the autumn and early winter the ewes are run on the clover or stubbles, receiving an occasional fold of rape or early turnips, or mangel-tops, with chaff and a little cotton-cake. They often follow the feeding sheep,

clearing up all their leavings on the fold. The practice formerly pursued of giving in-lamb ewes a full allowance of turnips, is generally discontinued, it being found that they are much better without such watery food before lambing.

Lambing-time.—"When about lambing, the ewes are brought in at nights, into a covered shed or yard; or a moveable lambing-shed is taken into the open field, and protection against wind and rain is provided by means of hurdles wattled with straw, or one or two old waggons, part-loaded with straw, the shepherds giving them unremitting attention both day and night.

After Lambing.—"The ewes, after lambing, are well fed, having straw, chaff, or hay, and ½ lb. to 1 lb. of cake or meal, with roots. Whatever be the destination of the lamb, the ewe should at this time be liberally fed.

"When the lambs are two or three weeks old, they begin to eat food with their dams, and lamb-hurdles are often provided, allowing them to run before the fold and eat a little dust, linseed-cake, or bruised oats. A change of food for the ewes is desirable, as soon as it can well be given. Early rye or Italian rye-grass, or the second year's clover, with a few mangels, and ½ lb. each daily of cotton-cake, proves an excellent diet.

Castration.—"Castration of all male lambs not required for stock purposes is often done by drawing at ten to twenty days' old, or is done by searing at three months old.

Weaning.—"Weaning takes place at from three to four months old; where the lambs are early taught to eat artificial food, it is not desirable to delay it too long. On those farms where fat lambs are sold to the butcher at an early age, they remain with the ewes until sold.

"The lambs, when weaned, are either taken a distance away out of the sound of their dams bleating, or a double row of hurdles at a little distance keeps them apart, when they before long become pacified. The lambs are provided with a succession of green food, much importance being attached to a frequent change of diet. It is not well for them to graze on land which has been folded with older sheep, the rank luxuriant herbage of clover or grass produced by sheep-manure being unhealthy food for lambs, and causing scour.

Dipping Lambs.—"The lambs, after weaning, are all dipped in some preparation to destroy parasites, and to prevent for a time the attacks of the maggot-fly, which in some districts, especially where much timber exists, is very troublesome, blowing up on the wool, and unless quickly eradicated, spoiling the wool, and even sometimes killing the lamb."[1]

Scotch Flocks.

In Scotland the lambing period comes on later than in England. In some exceptional cases a few lambs are dropped in February, but the general time is from the middle of March till the third week in May. In the lower-lying and better favoured districts—especially with Border, Leicester, and half-bred flocks—the majority of the lambs may be dropped in March; but in exposed hill-farms lambing does not begin till about the middle or 20th of April, and frequently extends till the closing days of May.

Early Lambing risky.—The climate, probable supply of early spring food, and amount of shelter, are the considerations which mainly determine the time of lambing. In cold late districts early lambing is very undesirable, and can hardly lead to satisfactory results. The flock-owner is truly in a pitiable condition when struggling with a big flock of ewes and newly born lambs with a deficiency of shelter and little food for them, except what may be given by the hand. Heavy outlays may be incurred, and yet the results may be very disappointing. There are few points more essential in the successful management of a breeding-flock than this—that, as soon as the lambs are dropped, the ewes should be liberally fed and protected from excessive storms. In order, therefore, to ensure this as far as possible, it is desirable that lambing should be delayed till the rigours of the winter are past and moderately genial spring weather and a speedy growth on the pastures may be reasonably calculated upon. The period of lambing will thus vary with the local-

[1] *Jour. Royal Agric. Soc. Eng.*, xiv., 1878, 713.

ity and the system of tillage farming—which latter has, of course, much to do with the supplies of such extra food as roots, grain, and hay.

South of Scotland Flocks.

In the Border Leicester flocks in the south of Scotland many lambs are dropped early in March—some even in February. As a rule, in these flocks ample provision is made for the lambing-time both in the way of food and shelter. Comfortable lambing-pens are provided; and with turnips, hay, cake, and grain, and a run upon young grass, the ewes are kept so as to ensure a full supply of milk. Keeping up the supply of milk is the chief object to have in view, for without this the crop of lambs will be disappointing.

Orchard Mains Flock.—In his Prize Report on the management of the ewes and lambs under his care in the winter of 1887-88 and following spring, Alexander Burns, shepherd to Lords Arthur and Lionel Cecil, Orchard Mains, Innerleithen, Peebles, says:—

"The sheep under my care are Cheviot ewes—part with half-bred lambs and part with Cheviot lambs.

Park Sheep.—"The Leicester rams were admitted amongst the park sheep on the 22d October, and were withdrawn on the 24th November, when two Cheviot tups were admitted in their stead. The park sheep, which numbered 205, commenced to get a run of the turnip-break a week previous to the time of admitting the rams. The latter were five in number, and consequently had each an allotment of two scores of ewes. In addition to the regular fare of turnips and grass which the ewes were getting, the rams were fed with corn and bran, while I keeled them to indicate the proceedings.

Lambing.—"Dividing them into two lots, the first commenced lambing on the 18th March. The weather was very cold—in fact too severe for old sheep, not to speak of young lambs. The ewes were, perhaps, a little to the thin side in condition. Though they did not drop a great quantity of lambs, they lambed fairly well throughout, but always grew scarcer of milk, which no doubt might be attributable to the inclement state of the weather and the wretched state of the turnips, which were simply slush.

Inflammation.—"Four deaths occurred amongst the ewes during lambing. Five dropped dead lambs, and three of these ewes rank amongst the above deaths. The other death was that of a gimmer which exhibited signs of lambing in the morning, but which went about all day without ever making any effort to lamb. I lambed her all right at night, and both ewe and lamb looked as well and comfortable in the morning as wishes could desire. The lamb was full, and the mother eating her food and tending her little offspring with motherly anxiety and care. But before mid-day the lamb was sick and grievously swollen in the belly, and died shortly. The gimmer, just as I was about to give her another lamb, gave signs of inflammation. I applied carbolic to her of the 1 to 5 strength, but to no purpose. Doses were repeated at intervals of about from two to three hours, without abating in any way the virulent nature of the inflammation. In the morning she was ready for skinning. The other three were similar in every respect, except that they dropped dead lambs. After similar treatment, they were ready for skinning also. Whether the case presents itself as hopeless or not, I always like to apply carbolic, for the simple reason that it invariably proves itself an efficient factor in keeping down infection.

Lambing in a Storm.—"Turnips, with a little rye-grass hay, was the feeding the park ewes got during the season, and as each ewe lambed, she was housed for a time—the weather being so cold that young lambs could not do to be exposed to its severity. In fact, the 28th of March was almost too much for the old sheep. Both old and young, lambed or not, I made thorough against that notorious night. The sheep lambed very slowly at the beginning, which was greatly in their favour in such weather, as it not only allowed space to accommodate, but gave time for the bestowal of special care upon each individual ewe as she lambed.

"The percentage requiring assistance was on the whole very small—perhaps something like 10 or 15 per cent."[1]

[1] *Farming World*, 1888, 526.

A Perthshire Flock.

The first of three prizes offered by the proprietor of the *Farming World* for reports "On the Management of Ewes and Lambs," was won by Mr W. Sutherland, Peel Farm, Tibbermuir, Perth, who thus describes his practice—in the winter 1887-88 and following spring:—

"Our flock (in addition to a lot of blackfaced, into the treatment of which I shall not enter) numbered 138—comprising 45 Leicester, 14 Shropshire Down, and 79 half-bred and other ewes. On the 17th September 1 Shropshire and 1 Oxford Down ram were turned in amongst the half-breds; and on the 8th October, 2 Leicester rams amongst the Leicesters, and 1 Shropshire Down among the ewes of that breed. For about five weeks previously the rams got a daily allowance of about 2 lb. each of linseed-cake and oats; but once they were admitted to the ewes they had no extra feeding whatever given them. The rams were withdrawn from the three lots on the 20th December. The first of the ewes lambed on the 17th February, and, with one or two exceptions, the whole had lambed by the 15th April. Total, 245 lambs.

"The Leicesters dropped 77 lambs—14 singles, 27 pairs, and 3 triplets—one ewe being eild. The Shropshire Downs, 28—each having a pair. The half-breeds, 140—21 singles, 52 pairs, and 5 triplets.

"Two of the ewes died from inflammation, after very severe cases of lambing, and another was suffocated by a piece of turnip sticking in her throat. Seven deaths occurred amongst the lambs. Three weakly ones only survived for a few hours. Another lingered for ten days. Two died from diarrhœa, and another from some undefinable cause.

General Management.—"In order to explain the management thoroughly, it will be advisable to start with the treatment given a month previous to the time I intend letting the rams along with the ewes. If the season has been a favourable one, the latter will, on examination, be found in good condition, and, consequently, no hand-feeding need be resorted to; but if, owing to a deficiency of pasture, any of them are in rather poor condition, I separate these from the others and give them a daily allowance of about 1 lb. each of linseed-cake and oats—this brings them rapidly into condition, and is also likely to lead to an increase in the crop of lambs.

"When the rams are admitted the hand-feeding is discontinued. During the period the rams are with the ewes each of the breeds are kept separate, and previous to the rams being turned loose the breast of each is rubbed with keel, and this is repeated daily, so that the ewes that have been tupped are readily recognised. After the rams have been out for a week all the ewes served during that period are marked with a little paint on the shoulder; at the end of the second and third weeks those served since the previous markings have other distinctive marks put on them; and any that may come in season afterwards are left unmarked. By attention to this matter a deal of trouble is saved when the lambing season arrives.

"I keep the rams with the ewes rather longer than is customary, and find by doing so we have seldom any eild ewes, and I have frequently seen a "May" lamb as far forward by the end of the season as those dropped two months earlier.

"About the beginning of November the whole of the sheep are dipped for the winter.

"When the grass begins to get scarce a daily supply of turnips are given—a cart-load to a hundred sheep—and as much hay as they can consume without waste. A week before the first are expected to lamb the first-marked lot are drawn out and kept on pasture adjoining the steading, and in addition to turnips and hay are allowed a little linseed and cotton-cake mixed with oats. When the other lots get within a week of lambing they are also separated and the same feeding supplied. It is a mistake to have the ewes too fat at this time; but a much greater one to allow them to be in poor condition—and the latter will be found to be the most frequent error.

Abortion.—"With the exception of one season we have never had any cases of abortion. When this disease appears, inquiry into the circumstances connected with the outbreak usually reveals some mismanagement in the feeding. The use of frosted turnips is a fertile source of

the trouble, and the outbreak we had some years since I attributed wholly to this cause. On discontinuing the turnips and substituting an allowance of cake and corn for a time, no further cases occurred. Since then I have been careful to give only as many turnips during frosty weather as will be at once consumed without any being left lying over exposed to the frost; and in the event of the turnips getting frozen in the pits, as they occasionally do in very severe weather, I discontinue using them altogether, and give other feeding until fresh weather ensues.

Rupture.—"I have had a few cases of rupture among the ewes, caused by the weight of the lambs when near lambing. By getting a piece of strong sheet-iron curved to the shape of the ewe's back, and having a few holes pierced along both sides, and then passing a piece of sacking beneath the belly and tying it up to the plate, great relief is given.

Shelter.—"It is very important to have proper shelter available during the lambing season. More deaths occur among lambs from want of this during bad weather than from all other causes put together. I have two large open sheds, and another divided into pens about five feet square. I commence taking the ewes into the sheds a few nights before the first are likely to lamb, and after dark take a turn among them by lamplight. By doing so they soon get accustomed to their new surroundings, and are not so apt to hurt each other through fright as they might be if this practice were deferred until lambing had actually commenced.

Lambing.—"Once they commence lambing I take a look amongst them every two hours during the night. Should any of them require assistance I rub my hands with linseed-oil before handling them, and in any case where there has been much difficulty in lambing I inject a little carbolic oil into the womb to prevent inflammation, and give five or six drops tincture of aconite in a spoonful of water, repeating the dose in two hours after if any uneasiness is shown.

"After the ewe lambs I examine the udder and clip away any wool that might interfere with the lambs sucking, and then remove them to one of the pens and keep them there for a day or two till the lambs gain a little strength; after which, if the weather is not suitable for letting them outside, I divide one of the other sheds into spaces large enough to contain six or eight of the ewes with their lambs, giving sufficient room to afford the latter space for exercise.

"I find gimmers and young ewes sometimes careless in looking after their lambs, but by confining them in one of the pens for a few days they soon take to them without much trouble. In the event of two ewes lambing about one time, the one having a single lamb and the other triplets, I take one of the lambs from the ewe having three and put it along with the one having the single. By haltering her to a corner of the pen she takes to the stranger in a very short time.

"Occasionally it is necessary to bring up some of the lambs on cow's milk. I have often heard it said that the 'bother and expense' of doing so exceeded the profit; but in most cases I have found both bother and expense amply repaid. Once the lambs are a few weeks old they will readily eat a little cake and corn, and if a piece of early well-sheltered grass is obtainable, the milk can soon be in great measure dispensed with.

"As soon as the weather is suitable, I keep the ewes and lambs out on the pasture during the daytime, but never care about leaving them outside at night until the beginning of April, when the weather is more to be depended on. Before allowing many of them outside together I put a distinctive mark on each pair of twins, so that in the event of anything going wrong, the ewe and both lambs belonging to her can be recognised without trouble.

Inflammation of the Udder.—"I find inflammation of the udder somewhat common. In such cases I give 2 oz. Epsom salts in gruel, bathe the udder with hot water, and then rub with ointment composed of 2 oz. fresh butter, 1 drachm camphor, and one spoonful spirits of wine. In severe cases poulticing is necessary, so that the lambs must be removed from the ewe altogether.

Sore Teats.—"This season, owing to the cold unseasonable weather experienced for some weeks after lambing commenced, sore teats have been more

than usually prevalent among the ewes. I have found frequent applications of glycerine and olive-oil a very good remedy.

Castrating.—"When the lambs are about ten days old their tails are cut, and as soon as the weather suits, the youngest of the cross-bred tup lambs are castrated, a little turpentine being applied to the edge of the wound. The first-dropped lambs are usually too far forward in size and condition to risk castrating by the time the weather is mild enough for the operation, but as they are early sold off fat it is a matter of little consequence.

Fat Lambs.—"As soon as the grass has got a fair start, the Leicester and Shropshire ewes, with their lambs, are separated from the half-breeds—the lambs of the latter being intended for the fat market. I prefer to push them on as rapidly as possible, and therefore confine them to the young grass fields, and increase the quantity of hand-feeding, as the lambs will be taking a share of it.

Lambs for Breeding.—"The Leicester and Shrops are kept on the older pastures; their lambs being intended for breeding purposes, there is not the same necessity for forcing, and the hand-feeding is therefore discontinued.

"To keep the sheep in healthy thriving condition frequent change of pasturage is necessary.

Diarrhœa.—"A few of the lambs are sometimes attacked by diarrhœa. If it arise from the richness of the grass, a little castor-oil, sugar, and ginger (the quantity varying with the size of the lamb) will usually cure it; but should it proceed from coagulation of milk in the stomach, it is more dangerous, and frequently proves fatal. Occasionally a little hartshorn and magnesia given in water will effect a cure.

Clipping.—"The ewes are clipped about the beginning of June, and about the end of that month the whole of the ewes and lambs are dipped to prevent the attacks of maggot-fly, which is very prevalent on our land.

Weaning.—"On weaning the pure-bred lambs about the 1st of August (the crosses are all sold off fat long before then), I put the ewes to the furthest off pasture on the farm, out of sight and hearing of the lambs, which I keep confined in the fold for ten or twelve hours afterwards. By doing so they get hungry, and when allowed out at once commence eating in place of breaking away in search of their mothers, as they would otherwise be apt to do. By keeping the ewes on bare pasture for a few days, the milk rapidly dries off them; but I generally find it necessary to milk the most of them once or twice to relieve them. A week after weaning, I examine them all, and any found broken-mouthed or faulty in udders are drawn out and put on good pasture, getting also an allowance of other feeding, so as to have them early fattened. Those intended to be kept on are put on ordinary pasture.

"As soon as the lambs have got over the separation from the ewes, the ram lambs are separated from the ewe ones, and each lot put on the best grass available, a small daily ration of cake and oats being also given. The ram lambs are usually retained and sold as 'shearlings'; the best of the ewe lambs are kept to fill the vacancies caused by the drafting of the old and defective ewes; and the others are either sold in the end of the year, or kept on and disposed of the following season as 'gimmers.'"[1]

Hill Flocks.

Early Lambing Undesirable.—The lambing season, begun in the well-sheltered vales of the south-west of England, is wound up on the exposed hill-farms of the north of Scotland. On the higher sheep-ranges of Scotland, and the north of England and Ireland, vegetation is late in moving in spring, while severe snowstorms in the months of March and April are by no means rare occurrences. It is thus desirable that lambing should not take place in these parts till the spring season is well through—desirable in order that the young lambs may escape the rigours of a severe snowstorm, and that, after lambing, the ewes may not have long to wait for a bite of fresh young grass, which is so effectual in bringing on a full supply of milk.

From about the middle of April to the end of May is the most general period for lambing on hill-farms.

[1] *Farming World*, 1888, 525.

Hardiness of Hill Sheep.—Mountain sheep are not brought into lambing pens as is done with lowland breeds. They produce their young on the hillsides, and in average seasons the death-rate amongst hill lambs is wonderfully small. The vitality of these creatures when newly dropped is quite marvellous. A healthy blackfaced lamb will be on its feet and searching for the udder three or four minutes after it is born. It seems to care little for cold, and if the weather be dry and the ewe have plenty of milk the youngster will thrive rapidly, even although there should be snow and frost. Rain is more hurtful to lambs than cold with a dry temperature.

Shelter on Hill Farms.—It is therefore desirable that, even for the hardy hill sheep, some provision should be made whereby the more weakly lambs may have shelter in excessively wet cold weather. It may not be practicable to provide shed accommodation for the whole flock; but in heavy rains it would be well to have the weaker lambs drawn out with their mothers and put under a roof, where they should be left over night while the ground is wet and cold. For this purpose, it will be found useful to have some artificial shelter provided at suitable points throughout the farms. Little huts constructed perhaps of turf, hurdles, and bundles of straw or rushes, will entail little outlay or trouble in formation, and during inclement weather will be found of great benefit to the ewes and lambs. Ewes with weakly lambs can be accommodated comfortably in these scattered huts for a few days and nights, the shepherd carrying or having conveyed to them some hay and roots. It is desirable to have these huts at different points on the farm, so as to lessen the distance which ewes and weakly lambs have to be driven.

Before lambing begins the shepherd should see that the means of shelter—keb-houses, sheds, huts, or whatever name and form they may take—are in good order, and sufficient for the probable wants of the flock. If necessary, the shepherd should receive assistance in providing and repairing lambing shelter. A day or two of a man with a horse and cart may be well bestowed upon this work, to convey hurdles, posts, bundles of straw, and small supplies of roots and hay to convenient places on the farm for the formation of shelter to ewes and lambs. Forethought and carefulness in matters of this kind play a large part in the successful management of breeding flocks.

The necessity for these huts will much depend upon the amount of natural shelter on the farm. If the farm abounds in hills and hollows, with patches of rank heather, there will be little need for huts. The ewe will find a cosy bed for herself and her young by the side of a dry hillock or bush of heather. But when such natural shelter is deficient, artificial protection should be provided.

Typical Hill Flocks.—Describing the general system of management in the lambing season on average hill-farms in the north of Scotland, Mr George Brown, Watten Mains, Caithness, says:—

"On all hill farms there is more or less natural shelter, most of the ground being interspersed with knolls and valleys, and the high ground covered with heather, which forms excellent shelter for ewes and lambs. During the summer, autumn, and winter, the ewes are kept out on the hilly ground, and the straths and glens are preserved until within a fortnight of lambing. The ewe hirsels are then allowed access to these reserved pastures during the day, and are turned out again to the *mossing* or higher ground during the night. This fortnight of good feeding brings on a flush of milk as soon as lambing takes place.

"Large hirsels are divided, 500 being the usual number in each, and this number are in charge of two shepherds who work together. Before lambing begins, all the weak ewes, or those in low condition, are selected and either sent to arable land to be lambed, or taken home to a park which is usually found in connection with a pastoral farm, and there lambed, and fortified with extra feeding, being returned to their respective hirsels when they have regained sufficient strength. This park, when lambing is concluded, is preserved, so that a cutting of hay is obtained from it. On some farms there are three or four of these enclosures.

'All weakly lambs are also taken from the hill ground to be treated specially in

these home enclosures. After lambing, the ewes and lambs are driven from the low ground on to the hill ground over night, where, amongst the heather and undulations, the ewes find comfortable beds for themselves and their young.

"Late in the season when, through an abundance of grass, the lambs become very big and strong before lambing, there are often serious losses both of ewes and lambs."

Hand-feeding for Ewes.—There is much difference of opinion, and as great variety of practice, amongst sheep-farmers as to the feeding of ewes during stormy weather. It is contended, on the one hand, that hand-feeding should almost, at all hazards, be avoided, for the alleged reasons that, once indulged by such treatment, the sheep will not again forage so well for themselves on the hill pasture; that hill pasture is not sufficient in quantity and quality to afterwards maintain in a thriving condition sheep that have been once artificially fed, and that on this account when artificial food is once given it has to be continued every year. In former times this was no doubt the prevailing idea; but while it is still both preached and practised by many experienced and successful farmers, yet it is certain that a more liberal and a more artificial system of management is coming into favour.

Assuredly the point is one which demands the most careful consideration. No elaborate or universal system can be laid down. Each season, and each set of circumstances, must be considered separately; and the farmer must watch carefully the condition and progress of his flock, and his existing and probable supply of food, and decide for himself to what extent, if any, his ewes should be hand-fed. In itself the hand-feeding of hill sheep is unquestionably undesirable. It should therefore be resorted to only in cases of necessity—when the available supply of other food is manifestly inadequate, and with such ewes as are too thin and weakly to furnish their lambs with a sufficiency of milk.

With this consideration in view—that hand-feeding is to be resorted to only where it is necessary in order to ensure as far as possible the full and uninterrupted progress of the young lambs—the sheep-farmer will watch carefully the daily condition of affairs, and will not hesitate to call in the aid of such extraneous food as roots and hay when the time for its use has really arrived. A high death-rate, both of ewes and lambs, occurs on many farms owing to the reluctance and delay in resorting to hand-feeding. This inhuman system cannot be commended. It cannot be profitable. To allow ewes to perish or to fall off seriously in condition and in supply of milk for the want of a handful of hay and a few roots, simply because the animals may look for similar treatment in after years, is short-sighted in the extreme. Keep up the condition and vigour of the flock at all hazards. If liberal feeding does not pay, assuredly a starvation system will not.

It is well to remember that if the ewes are brought to the lambing in good, fresh, vigorous condition, there will be the less likelihood of extensive hand-feeding being then necessary. Ewes in lamb should therefore be well wintered, and never allowed to get low in condition or weakly.

Just before lambing begins, it would be well to draft out any ewes which seem to be exceptionally thin in condition, and take these for lambing to some low, well-sheltered field, where they may have good pasture or artificial food.

For whatever extra or hand feeding may be necessary, hay and turnips are most suitable. Cake and corn may be more speedily effectual in bringing round very weakly animals, but in their pampering influence on hill sheep these concentrated foods are more injurious than hay and roots.

Shepherds' Duties at Lambing-time. — The lambing season on hill farms is a time of hard work and much anxiety. As soon as lambing begins, the shepherd requires to see his flock three times a-day.

"His first round is made at early dawn, before the sheep have left their 'moorings,' when any requiring attention can be readily noticed. Some shepherds make this trip before breakfast, but this is not a good plan to adopt. When a shepherd leaves his house he never knows how long he may be detained; and going out hungry may cause him to leave his

work when he ought not to do so, especially in bad weather. On returning from his rounds he brings home any ewe that has lost her lamb. Having keb-houses at various parts of the hill is of immense advantage at this time, and saves not only the shepherd a lot of unnecessary work, but is much better for the sheep every way. Then there will be a number of such stock in the hospital individually requiring careful treatment, all of which he needs to see before returning to the house for a meal. There is no time for rest during the day, and no sooner is one journey finished than he starts on another, repeating the same morning, noon, and evening. Much depends on the weather, and the worse it is the more need there is for exertion and daily perseverance, which the shepherds, as a rule, never grudge in behalf of their flocks.

"In order to induce a ewe to take a stranger lamb under her charge, the skin of her own dead lamb is flayed and put on another lamb, when the smell of the old skin is usually enough to deceive and induce her to take kindly to the newcomer. Instead of adopting this method, which involves more or less labour, sometimes the ewe is milked, and the milk is rubbed over the skin of the lamb that is to be transferred to her care; and it is found that the smell of her own milk has the same deceptive effect as the smell of the old skin."[1]

Reviving Hill Lambs.—Hill lambs are remarkably hardy, and when the ewes have plenty of milk, the young creatures make rapid progress.

"Their first and most fatal enemy is cold or hunger. For reviving chilled lambs the shepherd carries constantly in his bosom a bottle of warm milk, and sometimes another containing gin or whisky, of which he supplies a mouthful in extreme cases of weakness. Lambs that are really prostrate with cold have to be carried to some place of shelter. Very often the shepherd's kitchen is turned into a hospital for subjects of this kind. In a stormy day it is not unusual to see 20 or 30 shivering lambs by his fireside, which his wife or children attend to while he is away on his rounds.

"Lambs are, however, never taken from their dams if it can possibly be avoided. There is often some difficulty in getting the ewes to own them again, the natural odour by which they are recognised by the mother having been dissipated by the heat of the fire, or from coming in contact with others of a different smell. A better method of reviving chilled lambs than warming them by the fire is to dip them in a tub of warm water, then, after wiping dry, wrap in a woollen cloth, and leave them beside the ewes in the keb-house.

"On recovery, care must be taken to accustom the lambs gradually to outdoor life. A sunny noon is a favourable time to set them out, but if the weather continues cold they should be housed for a few nights, until they are strong enough to withstand the elements to which they are exposed."[2]

After Lambing.

Lambing is usually completed in four or five weeks. The after-treatment of the flock varies in accordance with the class of sheep, and the objects in view. In pure-bred flocks, where ram-breeding is carried on to some extent, the lambs to be kept on as rams are early selected, and may be taken with their mothers to reserved pasture, where, from the outset, the ewe and lamb receive liberal treatment.

Castration.—The male lambs not to be kept as rams are castrated when from ten days to five weeks old. In some cases, indeed, castration is performed when the lambs are only two or three days old, but the more general plan is to delay from two to four weeks.

In hill stocks castration is not usually performed until the lambs are fully a month old; in other words, the ewes commence to lamb in the third week in April, and the "marking" takes place about end of May, varying a little according to circumstances and personal tastes. Some farmers have a decided objection against too early castration, as it tends to give a feminine appearance to the wedders, stunting the growth of horn, and weakening the neck too much.

Great caution is required in castrating

[1] *Blackfaced Sheep*, Scott, 118.

[2] *Ibid.*, 122.

lambs. It should not be done in rainy, cold, or frosty weather; nor should the lambs be heated by being driven before the operation. It is best performed early in the morning, in fresh weather, with a westerly breeze. The ewes and lambs should be driven gently into the sorting-folds, the ewes being run out and the lambs held back. One assistant should catch the lambs, and another hold them while the shepherd operates. It is not easy to catch the leg of a lamb with a sheep's crook, their small active limbs easily escaping through the loop; but it may be effectually used in hooking the front of the neck, when the captor rushes in upon the lamb and secures it. But the historic crook is now seldom used for this purpose, as the lambs when confined may be easily caught without it. On arable land, where there is no permanent fold, a few hurdles may be set up in the corner of the field and the lambs enclosed there, and let out as castrated.

Castration may be performed in this way: Let the assistant hold up the back of the body of the lamb against his

Fig. 248.—*Mode of holding a lamb for castration.*
a Scrotum. *c* Tail.

left breast and shoulder, and with each hand raise a hind-leg towards the body, securing them by the shank; while, to prevent farther struggling, a fore-leg is held firmly in connection with a hind one of the same side. The effect of this arrangement is to exhibit the scrotum to full view, as well represented in fig. 248. The shepherd with his left hand then causes the testicles to make the point of the scrotum smooth; and cutting through the integuments of the scrotum, with a sharp penknife in the right hand, first to one testicle and then the other, he protrudes both testicles forward with both hands, and seizes first one testicle with his teeth, drawing out the spermatic cord until it breaks, and then treating the other testicle in the same manner; and, on adjusting the wounded scrotum, the operation is finished.

Describing the system in the north, Mr George Brown, Watten Mains, Caithness, says: "The pen is provided with a half-door, outside of which stand the cutter and holder. The catcher enters the pen and catches the lambs anyway or anyhow: no man who knows his work will hurt a lamb, and a novice will soon learn by looking on. The catcher hands the lamb over the half-door to the holder, who waits until the cutter completes operations,—the latter using one knife for castrating and another for docking, and then lets it down outside the fold, where it quickly joins its mother."

Another mode of castrating lambs is to cut off the point of the scrotum, and extract both testicles through the large opening. The amputated wound takes a considerable time to heal, whereas the two simple incisions heal by the first intention. It is argued, however, by those who prefer the latter plan, that there is an advantage in the larger opening, as all discharges are more readily got rid of. Whereas when the smaller wounds heal with the first intention there would be no outlet for pus resulting from suppuration, and inflammation would therefore be likely to ensue. Both methods are largely pursued. The penknife should be clean and sharp, and the whole operation should be quickly performed.

Docking.—Advantage is taken of the opportunity afforded at castration to dock the tail, which in Scotland is left as long as to reach the meeting of the hams. In docking, the division should be made with a large sharp knife in a joint, when the wound will soon heal. The lamb, after being docked, is let down to the ground by the tail, which has the effect of adjusting the parts in connection with the castration. Ewe lambs are

also docked at this time, but they are not held up, being merely caught and held by the shepherd between his legs until the amputation is done.

In England, docking is performed at the third joint, which gives a stumpy appearance to the tail. The object of docking is to keep the sheep clean behind from filth and vermin; but as the tail is a protection against cold in winter, it should not be docked so short in Scotland as is done in England. Tup lambs, in order to strengthen the back-bone, are allowed to retain their full tails until one year old.

Risks from Castration and Docking.—The scrotum does not bleed in castration, but the tail often bleeds in docking for some time in two minute and forcible streams, though usually the bleeding soon stems. Should it continue as long as to sicken the lamb, a small cord should be tied firmly round the end of the tail, but not allowed to remain on above twenty-four hours, as the ligatured point would die by stoppage of the circulation of the blood, and slough off. In some instances inflammation ensues, and the scrotum swells, and even suppurates, when the wound should be carefully examined, the matter discharged, and the wound soon heals.

The advantage of performing the operation in the morning is, that the several cases may be observed during the day; and should the weather have changed for the worse towards the afternoon, the ewes, with the lambs that have just been cut, should be brought under shelter over night. Besides the state of the weather, one cause of inflammation is the scratching of the wounds in the scrotum by the points of the stubble amongst the new grass; and this irritation is most likely to be aggravated when castration has been performed by cutting off the point of the scrotum.

To avoid this source of irritation, the new-cut lambs should be put on new grass, where the stubble has been shorn by a reaping-machine, or on old grass, for a few days.

A Preventive.—Some farmers use a mixture of pure olive-oil and spirit of turpentine for dropping into the scrotum after extracting the testicles, and the results, to themselves at least, are satisfactory. This practice is pooh-poohed by some veterinary surgeons; but when a farmer who uses such a simple and inexpensive mixture very rarely has a death amongst his lambs, whilst his neighbour, who does not use anything, loses 5 to 10 per cent, we think he is justified in pursuing his own course.

Perhaps a still better preventive of inflammation would be a few drops of a solution of carbolic acid and oil poured into the scrotum.

Rig or Chaser.—Sometimes one of the testicles does not descend into the scrotum, when the lamb ultimately becomes what is called a rig or chaser—one which constantly follows and torments the females of the flock, when near him, from insatiable desire. It is not, as a rule, safe to rely upon such a ram for breeding, although we have known of his becoming a successful and prolific sire. His career should be soon put an end to. If one testicle comes into the scrotum and is taken away, or if neither comes down, the ram may be regarded as barren.

Lambing Risks.—Ewes and lambs are subject to several risks during the first four or five weeks. When they have passed through them in safety, the shepherd may calculate on his results—whether he has increased the breeding part of his flock in the proportion it should have increased. He is not satisfied with his exertions if he has lost a single ewe in lambing. What number of lambs he should have to every hundred ewes will vary greatly with the breed and other circumstances.

The death of single lambs is a vexatious matter to a shepherd, as not only breaking pairs, but imposing considerable trouble on himself in *mothering* lambs of stranger ewes. Yet the trouble must be undertaken, so as to retain the ewes in milk that have lost their lambs, and thus maintain them in the breeding state for future years. Hence the shepherd's anxiety to save the lives of single lambs, and hence, also, his pride in preserving pairs.

Bad Weather and Lambing.—In fine steady weather the shepherd's labour is comparatively easy; but when stormy or wet weather prevails, or comes at unexpected intervals, the number of lamb-

ings are not only accelerated, but every ewe creates more trouble, even in the day-time. "Daylight has many eyes," and permits him to observe casualties in time to evade their effects; but at night, in bad weather, with glimmering light, difficulties increase tenfold; and we are convinced that every owner of a large flock would find it repay him at the end of the lambing season, by preserving the number of lambs and ewes, to afford the shepherd assistance in the busiest period of the lambing, and especially in bad weather.

Look to the Pastures.—The state of the new grass-fields occupied by ewes and lambs requires consideration. Ewes bite very close to the ground, and eat constantly as long as the lambs are with them; and as they are put on the new grass in spring, before vegetation is much advanced, they soon render the pasture bare in the most favourable circumstances, and especially so when the weather is unfavourable to vegetation. In cold weather, in spring, bitten grass soon becomes brown. Whenever the pasture is seen to fail, the ewes should be removed to another field; for if the plants are allowed to be bitten into the heart in the early part of the year, the greater part of summer will pass ere they will attain any vigour. In steady growing weather there need be little apprehension of failure in the pasture. At the same time, overstocking grass should be avoided at all times. It not only incurs the risk of the clover plants being bitten into the heart, but the pasture soon becomes foul with the dung of the sheep. Of the sown pastures, consisting chiefly of red clover and rye-grass, the clover is always acceptable to sheep; and in the early part of the season young shoots of rye-grass are much relished by ewes.

Rest beneficial to Pasture.—On removing the ewes from the first to the second field, it is better to eat the first down as low as it safely can be for the plants, and then leave it unstocked for at least a fortnight, to allow the young plants to spring again, which they will do with vigour, and with a much closer bottom, than to pasture every field for a longer time with fewer stock. Such a field, eaten down to the end of May or beginning of June, and then allowed to spring afterwards in fine growing weather, will yield a heavier crop of hay than if it had not been pastured in spring at all. Although the whole of the young grass on a farm, pastured lightly with ewes and lambs in the spring, were to grow, as the season advances, more rapidly than the ewes could keep it down, it will never produce the fine sweet fresh pasture which field after field will yield that has been eaten down in succession, and then left to grow for a time.

Caution in Changing Ewes on Pasture.—But in removing ewes and lambs from a short to a full bite of grass, caution is required in choosing the proper time for the removal. It should be done in dry weather, and in the afternoon; because continued damp or rainy or cold wet weather renders new grass so succulent and fermentable that it is almost certain to produce the *green skit* in the lambs, although that sort of weather increases the milk of the ewes. In the after part of the day the ewes have not time to eat too much grass before nightfall.

No Lambing on Carse Farms.—Carse farms have, as a rule, neither a standing nor a flying stock of ewes, and consequently have no lambing season; neither have farms in the neighbourhood of large towns, nor dairy farms, nor pastoral farms for the breeding of cattle alone. Ewes and lambs are thus found chiefly on pastoral farms devoted to the breeding of lambs, and on farms of mixed husbandry.

Shepherding on Arable Farms.—On low country or arable farms with the softer breeds of sheep, from 200 to 300 ewes are about as many as one shepherd can superintend during the day, to render them the assistance they may stand in need of; to place the new-lambed ewes and lambs in shelter until they have both gained strength, and are able to take to the pasture; and, in case of bad weather, to supply them with turnips and hay, to enable them to support their lambs until the weather improves. If one shepherd fulfils these duties in the day, he does quite enough; so that it will be necessary to have an assistant for him in the night, to gather the ewes into shelter at nightfall, and to take a weakly lamb, or all the lambs that have dropped during the night, into sheds erected on

purpose, or into sheltered stells, as a protection against bad weather. To ascertain the state of his flock, he should go through them with a lantern at least every two hours, and oftener if necessary.

Shepherding Hill Sheep.—The hardy breeds of hill sheep need less attention, especially during the night. Indeed, the general plan is to leave the flock undisturbed during the dead of the night. The ewes and lambs are turned out to the dry lair over night, and there the shepherd looks over them carefully, perhaps as late as eleven o'clock, while he or his substitute returns to them as early as 3 or 4 A.M., when daylight is making its appearance. If the lair is dry and free from holes, into which young lambs might fall and get drowned, mishaps rarely occur amongst hill sheep in lambing, and a prudent hill shepherd disturbs his breeding flock as little as possible.

Hill Shepherds.—The observations of Little on the qualifications of a hill shepherd are valuable, as containing much good practical sense. "Much," he says, "of the success in sheep-farming depends on the skill and application of shepherds, as well as on the judgment of farmers. As the situation of a shepherd is one of considerable trust, he ought to be honest, active, useful, and of a *calm temper;* for if at any time a shepherd gets into a passion with his sheep, it is attended with great disadvantage in herding, or in working among them. I have known a hasty, passionate man, with a rash dog, give himself double the trouble in managing a hirsel of sheep, besides abusing the sheep, that a calm good-tempered man, with a sagacious close-mouthed dog, would have had in the same circumstances.

"The qualification required in taking care of a hirsel of sheep, is, not in running, hounding, and training dogs, nor in performing a day's work of any other kind, but in directing them according to the soil, climate, and situation of the farm, in such a manner as they shall obtain the greatest quantity of food at all seasons of the year. Their health and comfort should be carefully looked after by the shepherd; and if his exertions are made with judgment, they are of very great consequence to the farmer. It is not by walking much, and doing a great deal, that a shepherd is a good one; but it is knowing *where* to walk, so as to disturb the sheep the least, and by doing at the time whatever is necessary to be done. There is not an experienced shepherd, who has been any length of time on one farm, who does not, as soon as he rises in the morning, and observing the state of the weather, know almost to a certainty where to find every sheep on the hill, and will accordingly take his course to the places where he knows his presence is most wanted.

"The object in looking over a hill every evening and morning, is to ascertain if there be no trespassers nor disease among the sheep which require looking after. If any of your own or neighbour's sheep have trespassed, it is very foolish to dog or abuse them, for the more gently you can turn them back the better. If the boundary should be on the top of a height, to which sheep are apt to draw at night, it is better to turn your own a little closer to the boundary in the afternoon than to turn back your neighbour's, and it will answer the same purpose; and if the two flocks are gently divided in the morning, without dogs, they will become so well acquainted with their own side, that at the very sight of the shepherd they will take to it without further trouble.

"Those shepherds who dog, force, and shed much about a march, I consider them as bad herds for their masters as for the neighbouring farmer. If the boundary be a brook or low ground, where the sheep graze in the middle of the day, and if trespasses are likely to be considerable, the same plan of turning the sheep should be taken as on the height, except that they are to be turned down in the morning, and set out in the afternoon.

"When a sheep dies on the hill, or any disease appears among them, the dead or diseased sheep should be removed immediately, but particularly so if the disease is of an infectious nature. Looking regularly over a hill is of great consequence, also, in case of any sheep falling into a ditch, or lamb losing its mother, or when they are annoyed by flies or maggots, or by foxes or dogs worrying

them, or when they fall on their back and cannot get up again.

"All these incidents an active shepherd with a good eye will soon discover, however much a flock may be scattered over a farm. . . .

"In good weather the shepherd may possibly do all that can be done among the ewes in the lambing season; but in bad weather it is the farmer's interest to afford every necessary assistance, for the want of which, serious losses have often been incurred. . . .

"Knowing sheep by head-mark often saves a shepherd much trouble, particularly in the lambing season, and at all sortings of the sheep; yet there are many good shepherds who do not know sheep by head-marks, and there are some very ordinary ones who have a talent in that way. Every individual may be known by the *stock* mark.

"To possess the knack of *counting* sheep readily is of no small service to a shepherd, for he ought always to be able to count his flock when he makes his rounds on the hill. There are few shepherds, who accustom themselves to count sheep, who cannot, wherever they meet with them on a hill, count 100 going at large, or even 200; and it seldom happens that a greater number than 200 will be found together in an open hirsel. To know the number in the different lots is of great use in case of a hasty blast, as you can, in that event, know almost to a certainty whether or not any sheep are wanting, and from what part of the farm.

"A shepherd ought likewise to be able *to do any kind of work about a sheep-farm*, such as cutting lambs, smearing, slaughtering, dressing for the market, repairing stone-dykes, cleaning out drains, mowing grass, making hay, casting and winning peat-turf for fuel, &c.; but he ought at no time to neglect the sheep for such work.

"Shepherds are generally accounted lazy; but those who really care for their sheep will not be so. Much walking unfits a man for hard labour, as much as hard labour unfits a man for much walking; but labourers will generally be found more lazy on a hill, or among sheep, than shepherds at field-work." [1]

[1] Little's *Prac. Obser. Mount. Sheep*, 79-86.

Abortion among Ewes.

Ewes in lamb are liable to abortion, or slipping of the lamb, as it is termed, as well as the cow, but not to so great an extent, nor is the complaint considered epidemical in the sheep. Various causes produce it, such as severe weather in winter, having to endure much fatigue in snow, leaping ditches, being frightened by dogs, over-driving, feeding on unripe watery turnips, &c.

Great Outbreak in Lincolnshire.—In the winter and spring of 1883, a serious outbreak of abortion and premature birth occurred in the flocks of Lincolnshire; and an investigation, carried out on behalf of the Royal Agricultural Society by Professor J. Wortley Axe, brought out information and conclusions of considerable value.[2] The inquiry extended to 106 flocks, numbering 51,475 ewes. Of these, 6234, or about 12 per cent, aborted, and 1494 died.

Causes of the Outbreak.—Professor Axe arrived at the conclusion that the outbreak of abortion was not produced by any special and particular cause, but by the concurrent operation of several hurtful influences of a common character. These he enumerates as follows:—

"First and foremost stands the mischievous and fatal practice of feeding pregnant ewes exclusively on unripe watery roots, and especially on unwholesome filth-laden shells.

"Secondly, pain and suffering caused by protracted *foot-rot*.

"Thirdly, exposure to cold winds and heavy continuous rains.

"Fourthly, fatigue arising out of the deep and sticky state of the ground."

Unripe Roots and Abortion.—The clearest evidence as to the evil influence of exclusive feeding of in-lamb ewes upon unripe watery roots was obtained by Professor Axe. The turnip crop in that season was unusually abundant, and, owing to the mild winter of 1882-1883, continued to grow, and remained throughout the season in an unripe and exceptionally watery condition. Of the total number of ewes (about 7800) fed exclus-

[2] *Jour. Royal Agric. Soc. Eng.*, vol. xxi. (1885), 199.

ively on roots, no fewer than 19 per cent aborted; while, where the roots were supplemented by frequent changes to grass, the rate of abortion fell to 3 per cent, and to 1¼ per cent where the roots were supplemented by corn and cake, or some other substantial aliment. Significant enough, surely!

In reference to the high-pressure system of forcing the growth of roots by the free application of artificial manures, and the growing practice of sowing roots late, and beginning their consumption early, Professor Axe remarks that these are inconsistent with full maturation and ripening of roots, and that on this account "the desirability of a guarded and judicious employment of this description of food in the management of breeding stock cannot be too forcibly insisted upon."

He also very strongly objects to the "too common system which condemns pregnant ewes to live exclusively on filth-laden shells" behind other sheep, which get the best of the fresh roots.

Foot-rot and Abortion.—It was shown clearly that foot-rot contributed largely to the cases of abortion. In flocks where it prevailed to any extent the rate of abortion was 4½ per cent greater than in those in which there was no foot-rot.

Twins and Abortion.—The cases of abortion were much more numerous with twin than with single lambs. Indeed, for every abortion with a single there were six abortions with twin-lambs—pointing, as Professor Axe says, "to the existence of some debilitating cause unfitting the ewes with twins to meet the greater demands on their nutritive resources, while influencing in a less degree those with singles."

Preventive Measures.—As the results of his investigations into this Lincolnshire outbreak of abortion, Professor Axe submitted the following recommendations, with the view of avoiding similar occurrences:—

"1. That from the time ewes are placed on turnips to the time when they lamb down, they should receive a liberal amount of dry food, to be regulated according to the nature of the season and the condition of the roots.

"2. The quantity of roots should at all times be limited, and besides shells, a fresh break should be given every day after the hoar-frost has disappeared, and in the early spring the tops should be removed.

"3. Change from the fold to the open pasture twice or thrice a-week, or for a few hours each day, if convenient, is desirable, and especially when the lair is bad.

"4. Protection from cold winds and driving rains should be provided in stormy weather.

"5. Plenty of trough-room should be provided, and ample space allowed for the ewes to fall back.

"6. All troughs should be shifted daily, and set well apart.

"7. Dry food should be given at the same time as the fresh break of roots, to prevent crowding at the troughs.

"8. Rock-salt should be at all times accessible.

"9. Animals suffering from foot-rot, or other forms of lameness, should be removed from the fold, and placed on dry litter, and receive such other attention as the nature of the case may indicate."

Mr Henry Woods on Abortion.—Sheep-farmers have derived much benefit from the investigations regarding abortion in ewes which have been conducted by Mr Henry Woods of Merton, Thetford, Norfolk, agent to Lord Walsingham. He collected and published a mass of valuable information on the management of breeding-flocks and the causes of the prevalent and excessive loss of ewes from abortion—the facts having been gathered from four hundred flock-masters in all parts of the kingdom. In fifty cases of sheep management, where the feeding and results were satisfactory, there were 25,281 ewes; in that number the cases of abortion amounted to 126, and the deaths from all causes during the breeding season were 222. In fifty unsatisfactory cases, there were 21,682 ewes; and in these returns, twenty-two farmers had very heavy losses, while twenty-eight stated a total of abortions amounting to 1884. In forty of the reports there were totalled 1255 deaths. Thus, fifty satisfactory cases showed 1 abortion and not quite 1½ deaths for every 200 ewes; whereas the other cases showed 17½ abortions and 11½ deaths for every 200 ewes, though nearly one-half the abor-

tions and one-fifth of the deaths were not recorded.

Mr Woods on Preventing Abortion.—In his general conclusions, Mr Woods remarks:—

"A most careful analysis of the returns—in making which I have had some able assistance—shows that sheep fed on turnips *now* are not so healthy as sheep were when fed on turnips *some years ago*. As you will have imagined, and as it needs no philosopher to tell you, ewes fed on grass are much more healthy than when fed on turnips.

"It is very evident that sheep are not so healthy as they used to be. One reason is, I think, the land being farmed more highly for turnips; and I have repeatedly remarked that we lose more sheep after a heavy crop of turnips. I do not think the artificial manure of itself is the cause, beyond forcing a turnip into a *bad quality*, which frequently causes us great loss just at lambing-time. I think it must be clear to any person who has followed my remarks in giving details of cases, that swedes are proved to be unhealthy food for breeding-ewes. I might have adduced many other cases from my returns confirmatory of this. In the few instances where the ewes have done well when feeding on swedes, the daily supply has been limited, and there has almost invariably been an allowance of other food—as hay-chaff, with a liberal admixture of bran.

"I believe that the verdict of a large majority of the thinking and practical farmers and experienced shepherds throughout the country will be this,—that if we make it a rule to flush our ewes by stimulating food during the tupping season, to avoid feeding on swedes as much as possible, to limit the supply of other roots as far as circumstances will permit, to give a fairly liberal allowance of digestible, nutritious, and health-preserving dry food, and to run the ewes out on grass as much as possible (taking care never to over-fatigue them) before lambing, there will in future be far fewer cases of abortion and death amongst ewes than we have now to deplore, and many more strong and healthy lambs will be reared than at present.

"One other point is this. The ewes lost during lambing would appear from my returns to be greatest where short-woolled ewes have been put to long-woolled rams. The evidence, I say, is unquestionable that greater mortality attends lambing where short-woolled ewes are put to large-boned, long-woolled rams, than where the ewes breed after their own kind. Where cross-bred ewes are served by Oxford Down rams, the loss of ewes has been less than in the case of the short-woolled ewes served by long-woolled rams; and I presume the reason is that the half-bred ewes, having their parts more fully developed from the cross, are the better adapted to perform the functions required of them."

Youatt on Abortion.—It is stated by Youatt, that too liberal use of salt will produce abortion. It is scarcely possible to predicate abortion in sheep, on account of their woolly covering, but its immediate effects of dulness on the ewe, and of a redness under the tail, will be symptoms noticed by an observant shepherd. "The treatment after abortion," observes Youatt, "will depend entirely on the circumstances of the case. If the fœtus had been long dead, proved by the fetid smell of it, and of the vaginal discharge, the parts should be washed with a weak solution in water (1 to 16) of the chloride of lime, some of which may also be injected into the uterus. If fever should supervene, a dose of Epsom salts, timeously administered, will remove the symptoms. If debility and want of appetite should remain, a little gentian and ginger, with small doses of Epsom salts, will speedily restore the animal. Care should be taken that the food shall not be too nutritive or too great in quantity."

Ailments among Lambs.—Young lambs, as long as they are dependent on their mother for food, are subject to few diseases. A change to new luxuriant grass in damp weather may bring on the *skit* or diarrhœa, and exposure to cold may produce the same effect. As long as the lamb feeds and plays, there is little danger; but should it appear dull, its eyes watery and heavy, and its joints somewhat stiff, remedial means should immediately be used. "A gentle aperient is first indicated in order to carry off any offensive matter that may have accumulated in and disturbed the bowels;

half an ounce of Epsom salts, with half a drachm of ginger, will constitute the best aperient that can be administered. To that must be added 1 table-spoonful of sheep's cordial, consisting of equal parts of brandy and sweet spirits of nitre, housing and nursing."

But there is a species of apparent purging, which is a more dangerous disease than the skit. "In the natural and healthy state of the milk and stomach, curd produced by the gastric juice gradually dissolves and is converted into chyme; but when the one takes on a morbid hardness, and the other may have lost a portion of its energy, the stomach is literally filled with curd, and all its functions suspended. The animal labours under seeming purging, from the quantity of whey discharged, but the actual disease is *constipation*. It is apt to occur about the time when the lamb begins to graze, and when the function of the stomach is naturally somewhat deranged. Chemistry teaches us, that while a free acid produces coagulation of the milk, an alkali will dissolve that coagulum. Magnesia, therefore, should be administered, suspended in thin gruel, or ammonia largely diluted with water, and with them should be combined Epsom salts to hurry the dissolved mass along, and ginger to excite the stomach to more powerful contraction. Read's stomach-pump will be found a most valuable auxiliary here. A perseverance in the use of these means will sometimes be attended with success; and the little patient being somewhat relieved, the lamb and the mother should be moved to somewhat better pasture."

Watery food in the lambing season lays the foundation of a bad quality of blood, and probably causes a number of deaths in the flock.

"Besides looseness, lambs are at times subject to *costiveness* in the bowels. In the first few days of its existence the fæces they void has a very viscid consistence, which, when it falls on the tail, has the effect of gluing it to the vent and of stopping up that passage. On the removal of the obstruction by scraping with a knife, the symptom will also be removed. A worse species of costiveness is, when a few drops of liquid fæces fall occasionally to the ground accompanied by straining, as it is generally accompanied with fever that may be dangerous. Half-ounce doses of Epsom salts should be administered every 6 hours until the bowels are evacuated, after which both ewe and lamb should be turned into more succulent pasture, as the cause of the complaint is to be found in bare pasture in dry weather. In cases of *fever*, which may be observed from the dulness of the lamb and its quick breathing, the administration of tolerable doses of Epsom salts will generally avert the malady *at its commencement*."

Inflammation in Ewe's Udder.—After recovery from lambing, the complaint the ewe is most subject to is inflammation in the udder, or *udder-clap* or *garget*. Of this complaint Youatt gives a good idea of its origin and of its treatment: "The shepherd, and especially in the early period of suckling, should observe whether any of the ewes are restless and exhibit symptoms of pain when the lambs are sucking, or will not permit them to suck at all. The ewe, like the cow, or oftener than that animal, is subject to inflammation of the udder during the time of suckling, caused either by the hardness or dryness of the soil on which she lies; or, on the other hand, by its too great moisture and filth, or by some tendency to general inflammation and determination to the udder by the bumps and bruises, sometimes not a little severe, from the head of the lamb. If there is any refusal on the part of the ewe, or even disinclination, to permit the young one to suck, she must be caught and examined. There will generally be found redness and enlargement and tenderness of one or both of the teats, or sometimes the whole of the udder, and several small distinct kernels or tumours on different parts of the bag.

"The udder should be cleared of the wool which surrounds it, and should be well fomented with warm water, a dose of Epsom salts administered, and then, if there are no large distinct knots or kernels, she should be returned to her lamb, whose sucking and knocking about of the udder will contribute, more than any other means, to the dispersion of the tumour and the regular flow of milk. It may occasionally be necessary to confine her in a pen with her little one, in order that it may have a fair chance to

suck. A day, however, having passed, and she not permitting it to suck, the lamb must be taken away, the fomentation renewed, and an ointment, composed of 1 drachm of camphor rubbed down with a few drops of spirit of wine, 1 drachm of mercurial ointment, and 1 oz. of elder ointment, well incorporated together, must be rubbed into the affected part, or the whole of the udder, 2 or 3 times a-day. She must also be bled, and the physic repeated. If the udder should continue to enlarge, and the heat and tenderness should increase, and the knots and kernels become more numerous and of greater size, and some of them should begin to soften or evidently to contain a fluid, no time must be lost, for this disease is abundantly more rapid in its progress in the sheep than in the cow. A deep incision must be made into that part of the udder where the swellings are ripest, the pus or other matter squeezed out, and the part well fomented again. To this should succeed a weak solution of the chloride of lime, with which the ulcer should be well bathed 2 or 3 times in the day. When all fetid smell ceases, and the wound looks healthy, the friar's balsam may be substituted for the chloride of lime.

"The progress of disorganisation and the process of healing are almost incredibly rapid in these cases, and the lamb may sometimes be returned to the mother in the course of a few days. There are particular seasons, especially damp and warm ones, when there is a superfluity of grass, in which garget is peculiarly frequent and fatal. Without warning, the udder swells universally with hardened teats, which sometimes bring on great inflammation; and if that is not stopped in the course of 24 hours, part, if not the whole, of the udder mortifies, and the mortification rapidly spreads, and the sheep dies."[1]

Ewe and Lamb Box.—In case of an individual ewe, of a large flock of a pastoral farm, which has strayed a considerable distance from the shed erected to afford shelter to ewes, or has suffered in hard labour, or has a weakly lamb, or has twins which are apt to stray from her or she from them, or has been overtaken by a rude blast immediately after lambing, a contrivance to afford such a ewe

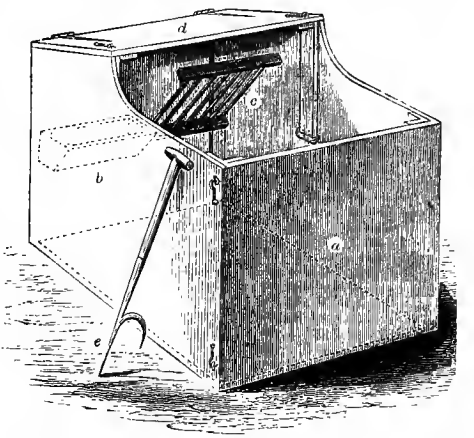


Fig. 249.—*Ewe and lamb house.*

a Movable front of box, with hooks.
b Manger within.
c Rack for hay.
d Broad lid with hinges.
e Fork to assist in lambing.

temporary shelter, used by Nicholas Burnett, Blaik Hedley, near Gateshead, and illustrated in fig. 249, seems to deserve notice. It consists of an enclosure of boards, or a box, whereof the front removes by hooks at the sides to admit the ewe and her lamb within, and where she is provided with a manger to contain sliced turnips or oilcake, and a rack for hay, to fill both of which access is obtained by a broad lid movable on its hinges. The box is light, and can be easily carried to any spot, and it might be the means of saving the lives both of ewes and lambs which would otherwise perish from exposure.

The size of this *ewe-house*, as it is called, may be made to suit that of the sheep bred on the farm; and as it is not costly, any number can be made to be used at a time. A useful size will be found to be the following: Length, 5 feet 6 inches; breadth, 3 feet; height, 3 feet; breadth of the covered part, 2 feet 7 inches; and rise of its slope, 7 inches. The fork leaning against the side of the ewe-house may be used to grasp a ewe's neck, while lying on the ground, and to fasten it down while the

[1] Youatt's *Sheep*, 497-515.

shepherd is lambing her without other assistance; but holding a ewe down between the heel and knee renders such an implement of little use.

Preparing Ewes for Railway Travelling.—Ewes with lambs at foot, unaccustomed to oilcake or hay, will get dry of milk on being sent on a long journey by steam or rail. But if accustomed with oilcake before, they will eat it readily on board ship or truck.

Snow in Lambing.—One of the greatest sources of loss among lambs on hill farms is a fall of snow at the lambing season, and a continuance of it after that period. Ground rendered wet by the melting of new-fallen snow is in a worse state for lambs than when wetted by rain, as rain falls at a higher temperature. Wet ground of any kind, however, is inimical to the safety of new-dropped lambs.

The driest part of the farm, combined with shelter, should be chosen for the lambing-ground, though it may be inconvenient in other respects. But should the best lambing-ground be covered with old snow, and in a sheltered spot, and the temperature of the air above the freezing-point, the snow might be removed.

Snow-plough.—A snow-plough would prove useful in its removal. The snow-plough, fig. 250, is thus described by Mr

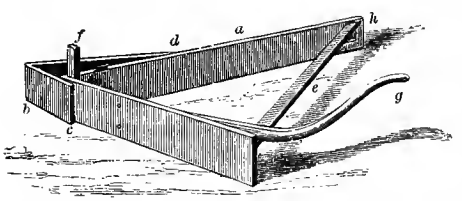


Fig. 250.—*Mountain turn-wrist snow-plough.*

a The plough.
b c d Shifting-head.
b c Head, 18 inches long.
b d Head, 30 inches long.
g Stilt, movable.
f Post for stilt, with a hinge-joint, and for draught-chain.
e Stretcher or cross-bar.
d h Mould-board in this arrangement.

Hepburn of Culquhailzie: "To enable the plough to clear tracks for the sheep along the hillsides, it is necessary it should be made to throw the snow wholly to the lower side. To effect this, I caused to be fitted to the plough—the body of which forms an isoceles triangle, whose sides are 7½ feet and its base 6 feet in length, the depth of the sides being 15 inches—a shifting head with unequal sides, one being 18 inches, the other 30 inches long, fixed by iron pins passing through 2 pairs of eyes attached to the head and to the sides of the plough respectively, so as to bring the point of the attached head of the plough nearly into the line of its upper side, or next the hill. A stilt at the same time was made movable by a hinge-joint at its anterior extremity, fixed to the bottom of the head from the post, so as to be capable of being fixed to a cross-bar or stretcher, either in the line bisecting the angle, which is the position for level ground, or in the line, alternately, of either of the sides, when to be used on a declivity. A draught-chain is fixed, not to the shifting head, but to the upright frame-post, in the nose of the plough, which rises 10 or 12 inches above the mould-boards.

"When the plough so constructed is to be worked along a declivity, with the left hand towards the hill, the shorter limb of the shifting head is fixed on the left side of the plough, near the point, and the longer limb on the right side, towards the middle; and the stilt being fixed in the left extremity of the cross-bar, nearly in a line with the temporary point, the plough is necessarily drawn in the direction of its left side, so as to throw the snow wholly to the right down the hill.

"When the plough is to return across the declivity, with its right side to the hill, the movable head is detached by drawing out the linch-pins, is turned upside down, and fixed in the reverse position; the shorter limb being attached to the right side, and the longer to the left side of the plough, while the stilt is brought to the right extremity of the cross-bar. The plough is then drawn in the direction of the right side, and the snow is thrown wholly to the left, near the lower side. Should the lower side of the plough show a tendency to rise, it may either be held down by a second movable stilt, fixed to the middle of the cross-bar, or a block of wood or other ballast weight may be placed on that side of the plough. The plough will be found to remove considerably more than its own depth of

snow. When a plough of 1 foot high passes through snow 18 inches or 2 feet deep, very little of the snow falls back into the track, and what does so fall is easily cleared out by the plough in returning."

Snow-harrow.—The snow-harrow, fig. 251, consists of a single bull, 4½ inches square, and 6 feet long; and in the middle of which, on the under side, a piece of 1¼-inch plank, 3 feet long, is

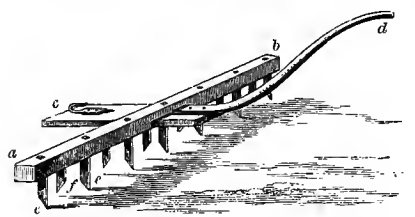


Fig. 251.—*Mountain snow-harrow.*

a b Bull.
c Plank, on which is the draught-hook.
d Stilt attached to plank.
e e 7 Long cutters.
f 6 Short cutters.

sunk flush transversely, for the attachment of a draught-hook and a stilt to steady the motion of the implement. In the bull are fixed, by screw-nuts at intervals of 10 inches, 7 cutters, &c., 9 inches long and 1⅜ inch broad, sabre-shaped, with their points turned backwards, so as to be less liable to be arrested by obstacles on the surface of the ground. Between these cutters are fixed six shorter ones, 3 inches long, having their points turned forwards. This implement, dragged by one horse ridden by a boy, and the stilt held by a man, cuts the frozen snow into stripes of 5 or 6 inches broad, which are easily pulverised by the feet of the sheep, or divided by the snow-plough.

In lowland farms the snow remains around the fences long after the middle of the fields are clear. A speedy means of getting rid of the snow is to cut it with the common plough repeatedly.

Hay-rack for Storm.—A cheap and most portable sheep hay-rack or heck for a storm, is the cart-horse hay-net, which can be fixed in spite of wind and drift, and will save hundreds of sheep where there is hay. Seven or eight sheep can get round one net, which will serve for years with care.

An excellent plan is to hang a wire net 1½-inch mesh upon a double row of ordinary net-stakes, care being taken to have the bag of the net low enough to prevent the sheep from passing under it. A hay-rack which will last for years, and of any desired length, may thus be made at a moderate cost.

But many think the best way of giving hay to ewes during a snowstorm is to lay it out in lines on the snow. Hill sheep will not, as a rule, eat hay unless they are confined, or the ground is covered with snow.

Sheep on Turnips.—The management of sheep on turnips in spring differs very little from that in winter, which has been fully discussed.

Produce of Lambs.

Single and Twin Lambs.—As to the probable produce of lambs, the following remarks by Professor Wrightson will be read with interest: "The number of twins or of single lambs is an important matter affecting the profits of sheep-farming. An abundance of twins is a matter for congratulation, but is not an unmixed advantage. They will not attain the size of single lambs for sale in the following autumn; the ewes require more food, and are often more reduced in condition through suckling, and the strain upon the mother is heavy, especially in the case of two-tooths. Still, a good many twins are required in order to keep up the number of lambs, which is liable to drawbacks from death, barrenness, and slipping. Twins give the opportunity to the shepherd of dividing them, and thus supplying lambs to ewes which have lost their own offspring, and which, otherwise, would go as barreners.

Crop of Lambs.—"Without a fair proportion of twins we should unquestionably suffer from a short supply of lambs, even upon the assumption of a lamb to a ewe throughout the flock. This apparently modest estimate is by no means always realised, in spite of twins, as barren and aborted ewes may easily constitute 5 per cent of a flock, and often double that proportion. Deaths among very young lambs are also frequent, so that the general statement that for every ewe put to the ram there should be a lamb at weaning-time, is not far from correct.

How to obtain a Big Crop of Lambs.—"Some flocks, and some farms, seem naturally adapted for producing a large number of lambs. It may be reasonably expected that twins will in turn produce twins, and hence rams and ewes which have been twins might properly be selected to propagate their species. Fertility is as likely to be inherited as any other property, and with it the natural accompaniments of good nursing and abundant milk-supply. I am inclined to think that ewes are naturally disposed to produce a pair of lambs, and that single lambs are to be regarded as a degree less normal than twins. Thus, when ewes are in good order and keep is abundant—both of which conditions must be regarded as strictly natural—the number of twins is immediately increased, and sometimes almost the whole flock produces doubly. This indicates the best method of obtaining a big crop of lambs, namely—keeping the ewes well throughout summer. Extreme fatness or extreme poverty both militate against fertility, but a judicious mean and plenty of good food during the period of conception produces an opposite effect. Ewes which have been barren during one season will often conceive early and produce two strong lambs the succeeding spring, and sale ewes which have been caked will generally produce a lot of lambs."[1]

Flushing—that is, forcing the ewes with rich and abundant food for a week or two before tupping, and during tupping—is known to have a wonderful effect in increasing the proportion of twin lambs.

Prolific Ewes.—Some remarkable instances of the prolificacy of ewes have been recorded. A ewe, the property of J. Amall, of Thrussington, Leicestershire, had the immense number of 22 lambs in six years. She had 3 lambs three times, 4 lambs twice, and 5 lambs once.—T. Stephens, of East Deanes, St Neot, had 12 ewes, which in one season produced 30 lambs—viz., 1 ewe, 4 lambs; 4 ewes, 12 lambs; and 7 ewes, 14 lambs.

Lambing Table.

The *duration of pregnancy* in the ewe is generally reckoned at *twenty-one* weeks, but may vary from 136 to 160 days.

From the following table, which shows when twenty-one weeks expire from the 1st and 14th of any month, the date for the lambing of ewes may be easily ascertained:—

From		To	
January	1.	May	27.
"	14.	June	10.
February	1.	"	28.
"	14.	July	12.
March	1.	"	26.
"	14.	August	8.
April	1.	"	26.
"	14.	September	8
May	1.	"	22.
"	14.	October	8.
June	1.	"	25.
"	14.	November	8.
July	1.	"	25.
"	14.	December	9.
August	1.	"	26.
"	14.	January	8.
September	1.	"	26.
"	14.	February	9.
October	1.	"	25.
"	14.	March	10.
November	1.	"	26.
"	14.	April	9.
December	1.	"	25.
"	14.	May	9.

MANURES AND MANURING.

In the advanced agriculture of the present day the question of manuring possesses far more importance and involves greater difficulties than were associated with it in the elementary farming of olden times. The extension and accumulation of knowledge, in regard to the maintenance, utilisation, and recuperation of fertility; the discovery and development of new sources of manurial commodities; and the vastly increased and still growing consumption of farm produce of all descriptions, have with their combined influence contributed largely to the great revolution which, since 1840, has taken place in British farm practice.

[1] *Live Stock Jour.*, p. 114, 1889.

The farmer can no longer wait for the recuperating power of nature to restore reduced fertility. He is not content to merely "turn over," as it were, the natural store of plant-food which the soil possesses. Before the advent of "artificial" manures and feeding-stuffs the prevailing system of farming was little else than a "turning over" of the inherent fertility of the soil—the abstraction of fertility from one field in certain crops, and the returning of it, or a great part of it, to another field in the shape of farmyard manure. This, however, was a slow process, quite unequal to the wants, the aspirations, and resources of the progressive age in which we live.

A speedier, more intense, more artificial system of farming has arisen, and to make provision for the greater demands which are now made upon the productive powers of the soil, active and persistent attention has for years been devoted by scientists, capitalists, and practical farmers to the all-important question of *manuring*. Indeed the development of the manure-trade is to some extent the cause rather than the result of the increased activity and progress of agriculture. They have grown up, as it were, hand in hand, the one fostering and encouraging the other.

By the discovery of vast natural deposits of manurial elements, and by the manufacture of useful fertilisers from waste products and other material, great possibilities, hitherto undreamt of, have been placed in the hands of the farmer. By the means of these agencies it is possible for him to vastly increase and hasten the production of his farm—not only by adding to the supply of plant-food already in the soil, but also by so stimulating, equalising, and preparing that supply, as to render it far more serviceable and nutritious to the growing crops.

The farmer is not now dependent upon the residue of his crops for the restoration of fertility to the soil. So far as concerns the question of the fertility of the soil, the farmer may now grow what he pleases and sell what he pleases. The abstracted fertility may be replaced by purchased fertilisers, so prepared and proportioned as to return to the soil in the most useful form the exact quantities of the elements of plant-food withdrawn by the crop.

It is not to be said here that this system of selling crops and buying artificial manures is preferable to the older and still more general method of consuming a large portion of the crops on the farm, and so restoring fertility by farmyard dung. The point is mentioned merely for the purpose of indicating the vastly extended scope which the development of the manure-trade has imparted to the practice of farming.

It is thus seen that the subject of *manures and manuring* is now one of surpassing importance. It has, indeed, become the very keystone of British agriculture. We have therefore deemed it right that in this edition of *The Book of the Farm* the subject should receive somewhat exceptional attention. It is dealt with more fully than has before been attempted; and while dogmatism as to the precise composition and quantities of specific manurial doses has been avoided, an effort is made to submit in convenient form such information as will safely guide the intelligent farmer in the economical and efficient manuring of his land.

There is probably no process connected with agriculture as to which there is more difference of opinion, or in which greater diversity of practice prevails, than the manuring of land. This remark, too, is quite as applicable to professional chemists as to practical farmers. To attempt to reconcile all these contradictory views and customs would be hopeless; yet in the majority of cases the contradiction is more apparent than real. The more intimately one becomes acquainted with the routine of farm management in the various parts of the British Isles, the less is one inclined to dogmatise and to assert that a certain system is right and all others wrong. The system which gives the best results in the cold regions and light friable well-drained lands in the north of Scotland, may be utterly unsuited to the stiff clayey lands of England, or the moist soil and mild climate of the Emerald Isle. One may be assured that the marked divergences in farm practice are not mere accidents. As a rule, they will be found to be fully justified by

variations in local conditions, differences in soil, climate, and objects and possibilities of the farmer. Then, as to the differences amongst men of science, it should be borne in mind that the great field of agricultural chemistry is only in process of exploration, and that while our knowledge regarding its wonderful truths has, in recent years, grown with gratifying rapidity, it is still far from being perfect and entire.

In dealing with the subject of manures and manuring, the Editor has been deeply impressed with these considerations, and, keeping them in view, he has sought the counsel of many recognised authorities. The writings of our most eminent chemists and practical agriculturists have been carefully consulted and freely drawn upon, notably those of Johnstone, Cameron, Voelcker, Anderson, Lawes, Gilbert, Wilson, Sibson, Morton, Ville, Liebig, Hellriegel, Wrightson, Warington, Aitken, Jamieson, Falconer-King, Aikman, MacAdam, Bernard-Dyer, Lloyd, Cooke, Fream, Curtis, Brown, &c. And from several experienced practical farmers, who have made a special study of the subject, and who reside in and farm different parts of the kingdom, the Editor has received most valuable help and advice in his effort to present the readers of this work with useful information as to the economical manuring of land.

EXHAUSTION AND RESTORATION OF FERTILITY.

In the section on "Fertility of Soils" (p. 56, Div. I.), the principles relating to the existence, exhaustion, and restoration of fertility in soils are fully explained. The reader should be familiar with what is said there before perusing what follows here.

Abstraction of Fertility.—It has been seen that the fertility of the soil becomes reduced by the removal of ingredients in crops and animals raised upon it, and by soluble matters being carried away in drainage-water. It is also more than probable, as will be explained in connection with the Rothamsted experiments in this chapter, that loss of plant-food occurs through evaporation of volatile ammonia.

Prior to the introduction of artificial manures, farmers relied almost entirely upon farmyard dung to replace the abstracted fertility. This, however, was not sufficient, for much of the ingredients of the soil were sold off in the form of grain, meat, milk, cheese, &c. It is thus obvious that, if no other means of restoring fertility had been found, the soil would have, in course of time, become exhausted.

Deferring Exhaustion.—The agents which were most effective in deferring this exhaustion were careful and seasonable tillage, drainage, subsoiling, the decay of the roots of crops, rotation of crops, and bare fallow. The combined influence of these agents is certainly by no means insignificant. It has been well shown in the Rothamsted experiments that tillage and the decay of the roots of crops have a very important bearing upon the duration of fertility in soil.

It is a curious and important fact that the growth of crops in itself, while robbing the soil of certain ingredients, tends to enrich it in other elements of fertility. The plants absorb nitrogen from the atmosphere, and draw nutritious ingredients from the subsoil. By the decay of their roots they thus leave the surface soil richer in certain elements than it was before. And the larger the crop the more does it enrich the soil in these elements, for the greater is the residue of plant-food in the roots which remain in the soil. See pp. 60 and 61, Div. I.

Restoring Fertility.—But it is clear that something more is necessary to restore to the soil the particular elements removed in the produce exported from it. For this restoration we have now at hand an exhaustless store of artificial manures.

Ingredients Removed by Crops.—The important question now arises: What are the ingredients which are removed in crops, and what are the quantities of each? As to the elements of plant-food and the sources of their elements, see p. 57, Div. I.

On p. 63, Div. I., will be found an exhaustive table, showing the weight and average composition of ordinary farm crops in pounds per acre. From that table it is easy to calculate the quantity of each ingredient of plant-food removed in any rotation of the ordinary farm crops.

And from the full explanations which accompany the table, useful deductions may be drawn as to the manurial treatment which should be pursued under the various systems of cropping, stocking, and disposal of crops and stock.

The subject is so fully and clearly dealt with by Mr Warington, in the pages referred to, that any further discussion here of the general principles relating to the exhaustion and restoration of fertility would be needless repetition.

Exhaustion in a Norfolk Rotation.—It may be interesting to show here in tabular form the quantities of the chief elements of plant-food which would be withdrawn from the soil in the course of the Norfolk rotation of wheat, turnips, barley, and clover; and with this total is contrasted the amount of these ingredients which would be returned in an ordinary dressing of farmyard manure—8 tons or 16 yards of dung :—

Crop.	Dry Matter.	Nitrogen.	Potash.	Magnesia.	Phosphoric Acid.
	lb. per acre.	lb. per acre.	lb. per acre.	lb. per acre.	lb. per acre.
Wheat, 30 bushels per acre . .	4183	48	28.8	7.1	21.1
Turnips, 17 tons " . .	4657	112	148.8	9.5	33.1
Barley, 40 bushels " . .	3827	48	35.7	6.9	20.7
Clover, 2 tons " . .	3763	102	83.4	28.2	24.9
Totals . . .		310	296.7	51.7	99.8
Rotten farmyard dung, 8 tons per acre		96.8	95.2	18.94	48.0
		213.2	201.5	32.76	51.8

It is thus seen at a glance that an ordinary dressing of farmyard manure, say 8 tons or 16 yards per acre, applied once in the above four-course rotation, would restore barely one-third of the elements of fertility removed by the crops. Such a large dressing as 24 or 25 tons of dung per acre is impracticable; hence the economy and advantage of having at command the various artificial fertilisers in which, in a highly concentrated and readily available form, the deficient elements may be supplied.

Removal and Return of Plant-food in Different Systems.—This supplemental work is indeed the chief function of artificial manures. Upon all farms, less or more farmyard dung is made; and as a means of restoring fertility, it is first reckoned upon and employed. Under certain systems of farming, where not only the great bulk of the produce of the farm, but also large quantities of purchased foods, are consumed on the farm by stock, the quantity of dung may be almost sufficient for all the manurial requirements of the holding. Indeed, under such a system, the manurial residue of the purchased foods might supply more plant-food than would be exported from the farm; and thus, without the aid of any of the artificial fertilisers, there would be an accumulation rather than an exhaustion of fertility. But extreme cases of this kind are very rare.

The extreme on the other hand is where the growing and selling of crops are the main features in the system of management, and where few or no stock are kept beyond what is necessary for the working of the farm.

Between these two extremes there are many gradations—an endless variety of systems, in which there is an ever-changing relation between three great factors in successful agriculture—viz. (1), the amount of plant-food withdrawn from the soil; (2) the amount returned in farmyard manure; and (3) the quantity of purchased fertilisers necessary to make up the deficiency in the latter, as compared with the first, or to furnish any increased fertility which the farmer may desire to impart to the land.

Sum and Substance of Successful Manuring.—Here, then—in securing the proper relations of these factors—we have the sum and substance of successful

manuring. It is by no means a simple matter. It is beset with many problems requiring the most careful and intelligent study, as well as technical knowledge. The farmer has to consider not only what quantities of the various elements of plant-food he would have to purchase to make up the deficiency in his supply of farmyard manure. He must also see that he procures these elements from the best and cheapest sources at the time, and that they are in the forms most suitable to his objects.

And it has to be kept in view that the ascertaining of the amount of purchased manure necessary to supplement the farmyard dung is not the simple matter the uninitiated might at first sight regard it. It is not sufficient to merely subtract the supply of plant-food in the stock of dung from that contained in the crops removed from the soil. For instance, we have seen from the table on page 90, that during the four-course rotation there mentioned the quantities of plant-food removed in the crops would exceed those returned in 8 tons of dung by 213 lb. of nitrogen, 201.5 lb. of potash, 32.76 lb. of magnesia, and 51.8 lb. of phosphoric acid, per acre.

Resources of the Soil to be Reckoned.—Now it is not enough for the farmer to have ascertained this. If he were to supply the full quantity of each ingredient here represented as deficient, he would most likely be pursuing a wasteful system of manuring. The natural resources of the soil must be reckoned with. In many soils there is a great natural store of certain elements of plant-food, which will be capable of furnishing the wants of crops for several years to come. For instance, if it is a clayey soil, there will most likely be such an abundance of potash in it as that any direct application of this element would, for the time being, be entire waste of money, perhaps even hurtful to the crop.

The farmer has therefore a fourth factor to reckon with—namely, the *reserve* of plant-food in the soil.

Chemical Analysis Unreliable.—The accurate ascertaining of the quantity and condition of this "reserve" of plant-food in the soil is perhaps, of all, the most "knotty" point in the whole question of manuring. The acumen of the chemist fails in this particular point. By the aid of his powerful acids, alkalies, and other decomposing agents, he can tell us the entire quantity of any element in the soil and subsoil; but he has not as yet succeeded in determining definitely how much of that element exists in a form available to the plant, and how much of it is locked up in combinations which the weaker acids at the command of the plant are unable to break up. True, by diluting and weakening his acids and alkalies, so as to bring them as near as possible to the strength of the dissolving agents at the command of the plant, the chemist endeavours to *estimate* the amount of *available* plant-food in a soil. In this way he is able to obtain information of undoubted value. Yet it is merely an *estimate*, and in practice has to be followed with caution.

Evidence of the Crops.—Recognising the difficulty of accurately estimating the fertility of soil by analysis, Georges Ville, the eminent French chemist, recommended the more elaborate and more reliable plan of testing the soil by the "evidence of the plants themselves." He says:—

"I laid down the principle that by means of four substances—phosphoric acid, potash, lime, and nitrogenous matter—it was possible to bring the most barren soil to the highest degree of fertility. We have learnt more than this—viz., that these four substances, however efficacious they may be, only remain so as long as they are associated and united one with the other; for by suppressing one, the remaining three are often rendered inert, and frequently lose the greater part of their activity.

"We have further said that these four substances are not of the same degree of utility to all descriptions of plants, but that each has a preponderant or subordinate action by turns; that for cereals, colza, and beetroot, nitrogenous matter was the preponderant constituent; phosphoric acid fulfils a similar function with respect to maize, cane-sugar, and swedes; whereas potash preponderates in the case of potatoes and leguminous plants. If you thoroughly understand these three fundamental propositions, you will readily see by what natural deductions we shall

be able to found upon them a practical method of analysis that will be accessible to all.

"Suppose, for instance, that we experiment upon the same soil with five different manures: first of all, a manure composed of the four substances of which we have been speaking, and to which we have given the name of normal manure; and next with four manures composed of three ingredients only, excluding in rotation nitrogenous matter, phosphoric acid, potash, and lime, and with these produce a parallel series of crops—

With the normal manure.
Manure without nitrogenous matter.
" " phosphates.
" " potash.
" " lime.
The soil without any manure.

The result will be that the complete manure produces 43 bushels of wheat per acre; manure without nitrogenous matter produces 14 bushels; manure without phosphates, 26½; manure without potash, 31; manure without lime, 41; and the soil without any manure, only 12 bushels per acre.

"The conclusion is evident and conclusive. The soil requires, above all, nitrogenous matter; it is provided with lime, but insufficiently supplied with potash and calcic phosphate. What analysis, I ask, be it as delicate as it is possible to conceive, will ever be able to furnish us with a series of results like this? According as the crops obtained with the incomplete manures differ from or resemble those resulting from the use of the normal manures, the conclusion we arrive at is, that the soil lacks the ingredient excluded from these manures, or *vice versâ*.

"But this is not all. In every soil there are two portions to be considered —the surface soil and the subsoil, the upper and under layers—and it is most important that we should have definite ideas upon this subject. We may gain the necessary knowledge very easily by substituting for wheat some tap-rooted plant; beetroot, for instance, which buries itself in the ground to a much greater depth.

"With potatoes, the information gained is no less instructive and precise:—

	Crop per acre of Potatoes.	
	tons.	cwt.
Normal manure . .	11	3
Manure without lime .	8	4
" " phosphate	6	6
" " nitrogen	5	18
" " potash	2	2
Soil without manure .	2	14

The potato, then, tells us that the soil of Vincennes does not contain sufficient proportions of potash and of nitrogen; and if it shows a preference for soil that is rich in potash, it is because that substance is its dominant constituent—that is to say, it is the ingredient in manure that acts most beneficially upon that special crop.

"The evidence of these two plants is not contradictory but confirmatory, and you will observe how the preponderance of certain constituents gives an additional value to the same facts. In order to gather an exact idea of the richness of the under layer or subsoil at Vincennes, it is necessary to consider the result which was obtained at the same time with wheat and potatoes. A series of crops of wheat shows plainly that nitrogenous matter and potash are present in restricted proportions, and a series of potato crops confirms and ratifies this testimony; only with manure without potash, the crop of potatoes is feebler and comparatively smaller than that of wheat, because potash is a dominant constituent in potatoes, and only a subordinate constituent in wheat.

"Here, then, is a perfectly accurate system of experiments, and the information gained may at once be applied to practical use. With an experimental field we always determine the nature of the substances useful to plants contained in the soil, and also determine in what constituents the soil is deficient, and with this knowledge we can decide what sort of manure it will be advisable to employ.

Method of Test Experiments.—"I will briefly show you how we should proceed in the formation of such fields, according to the purpose for which they are to be used. If the results of our experiments are somewhat important, we must choose a piece of land representing the mean fertility of the whole estate, and divide it into ten plots, each containing,

say, a quarter of an acre, to be fertilised, as shown beneath :—

No.	1	is to receive 24 tons of farmyard manure.
"	2	" 12 " "
"	3	" very rich normal manure.
"	4	" ordinary "
"	5	" manure without nitrogenous matter.
"	6	" manure without calcic phosphate.
"	7	" manure without potash.
"	8	" manure without lime.
"	9	" manure without mineral matter.
"	10	" soil without any manure.

Here is a system equal to all the exigencies of every kind of culture. Thanks to this method of growing crops side by side, we are able to follow methodically the exhaustion of the soil; that advanced-guard of the field of experiments indicates with certainty the precise moment when the soil is ready to receive nitrogenous matter, potash, or calcic phosphate, as the case may be.

"But it will be said that on every farm it may happen, as it nearly always does, that there are soils of very different nature. The experimental field, of which we have just been speaking, does not suffice for an extended inquiry, and in order to arrive at useful results, it is necessary to set aside an additional quarter of an acre, divided into four parts, on which to experiment with these different manures: normal manure, mineral manure, and nitrogenous matter, the fourth part receiving no manure at all.[1] With these four combinations of manure, under the condition that if necessary the trial may be repeated, we can acquire with certainty all information of which, practically speaking, we have need. The first field, by reason of its greater extent, and the more numerous and varied combination of manure that it receives, is, as it were, a centre towards which all the others must gravitate. The results given by the smaller plots are tested by those of the first field, which acts as a sort of touchstone, and in a certain measure completes and rectifies their signification. When you are once familiarised with this mode of investigation, every kind of culture becomes a source of information concerning the state of the soil—its richness or its exhaustion. Here, for instance, is an example :—

"On two contiguous portions of land, say of a few square yards, sow peas and wheat without any kind of manure. This little experiment will amply suffice to ascertain if the soil contains nitrogenous and mineral matter. We have already seen that nitrogenous matter was the dominant constituent in wheat, and that it was only of very secondary importance to peas, if indeed its action could be regarded as of any use at all to them; whilst the dominant constituent in peas was potash. You see now, by the light of these simple facts, with how much importance the experiment just quoted can be invested. If the two squares of wheat and peas are equally fine, it proves that the soil contains a sufficiency both of nitrogenous and mineral matter.

"Now, if the wheat becomes small, yellow, and rather soft, whilst the peas flourish well, it proves that the soil is lacking in the dominant constituent of wheat, which is nitrogenous matter, whilst it contains, on the contrary, a sufficiency of mineral matter, and above all of potash.

"We will extend the range of our observations. Lucerne has roots which penetrate deeply into the subsoil. It is from these under layers that it principally obtains the mineral matter, of which it requires a large quantity. Suppose that lucerne prospers whilst peas are weakly. What are we to conclude from this? That the superficial layers of soil are lacking in potash and phosphates, whilst the deep layers are provided with them; but if the two plants progress equally well, we know that the superficial and deep layers of soil are well provided with mineral matter." [2]

Farmers' Experiments.—Mr F. J. Cooke, Flitcham Abbey, Norfolk, in a paper read before the London Farmers' Club, on March 25, 1889, urged farmers to make trials upon their own land as to

[1] The best arrangement as to experimental plots in fields is to select so many drills if the crop is roots, or so many ridges or yards wide if corn or pasture, so that each plot may run from end to end of the field, and thus, as far as possible, embrace all the variations in the character and condition of the soil.

[2] *Artificial Manures.* G. Ville, 176-183.

the kinds and quantities of manures best suited to their farms. He stated that he had been doing so himself annually for some twenty years, and he was not aware of any other separate practice which had been so useful to him. The information he thus obtained had saved him much unprofitable outlay on manures which had formerly been unnecessarily or imprudently applied.

Mr Cooke's method of testing the wants of the soil and the crops is quite simple, and similar to that recommended by Ville,—namely, the use of the four necessary elements of plant-food—nitrogen, phosphoric acid, potash, and lime—*separately* and together, and as far as possible in the most economical forms,—one plot remaining unmanured, another having all the ingredients, whilst upon the other plots each ingredient is in turn omitted.

An interesting example of the value of experiments in discovering the manurial wants of separate farms, and of the unreliability of chemical analyses of soils for this purpose, is given by Mr Cooke. A dressing of 3 cwt. of nitrate of soda and 3 cwt. of superphosphate was applied to a plot of barley at Flitcham, upon which the crop failed. An adjoining plot got these manures, and in addition 2 cwt. of muriate of potash, and produced 54 bushels of barley per acre. Yet the soil of both the plots was found by chemical analysis to contain as much potash in the top foot of it as would be found in 3 tons per acre of muriate of potash. There was an abundance of potash in the soil, but it was not available to the barley. Hence, on this soil an application of potash was essential for profitable cropping, and no amount of other manures would succeed without it.

All this tends to show not only the importance of, but also the difficulties involved in, the question of manures and manuring. In arranging the dressings of manure to be applied, the farmer must consider the probable contents and condition of the soil, as well as the wants of the particular crop. He will endeavour, as fully as possible, to utilise the "reserve fund" of fertility in the soil, and aim in particular at having the crop provided with a supply of plant-food, which will not only be ample in quality, and present in an available form, but likewise contain in *due proportion* all the essential elements of plant nutrition.

Law of Minimum.—This due proportioning or balancing of the elements of fertility is a point of the utmost importance. It is illustrated by what is known as Liebig's law of minimum. Every soil contains a maximum of one or more, and a minimum of one or more, of the ingredients necessary for plant growth. Now the growth or produce of the plants on this soil is governed not by the combined quantity of all the ingredients present in the soil, but by the producing power of the essential ingredient present in the smallest proportion, no matter how small a part this deficient element may play in the economy of the particular crop. Again, let it be remembered that the strength of the chain is governed by the weakest link.

The object of manuring is to provide against deficiencies of this kind, and at the lowest possible cost to furnish the crops with a full supply of readily available well-balanced wholesome plant-food.

VARIETIES OF MANURE—FARMYARD DUNG.

In a description of the various commodities employed as manure, the first place naturally falls to *farmyard dung*. At one time the only kind of manure available, it is still, in this connection, the mainstay of the farmer. Its pre-eminence is gradually lessening, yet it will always be an important agent in maintaining the fertility of the farm. There are now many farmers who depend more largely upon artificial manures than upon dung. Upon the whole, however, "muck" is still the staple manure, and artificial fertilisers merely supplementary to it.

Variety in the Quality of Dung.—Farmyard manure consists of the solid and liquid excrements of farm live-stock, and of the litter provided to them. Except when made and kept wholly under roof, it also contains a considerable quantity of rain-water. Its manurial value depends upon the class of animals by which it is made, the age of these animals, the kinds and quantities of food supplied to them, the kind and quantity

of litter employed, and the manner in which the manure is made and managed generally—whether well trodden, evenly mixed, the fermentation kept duly in check, and waste prevented.

In the chapter on the "Treatment of Farmyard Manure" (p. 501, Div. II.), information is given, not only as to the "making" of good and bad dung, but also as to the characteristics of the different kinds of dung. In this connection the succeeding chapter on "Liquid Manure" (pp. 514-529, Div. II.) should also be consulted.

The system of feeding is mainly responsible for the original quality of the dung. The feeding of draught-horses varies but slightly, so that farm-horse dung is comparatively even in character. With cattle—by which the great bulk of farmyard manure is made—the case is very different. All sorts of dietary are given to them; from very poor and scanty—such as will barely sustain the existing "condition" of the animal—to very rich and abundant, far beyond the power of the animal to assimilate. Then in one case the supply of litter, generally cereal straw, which has little manurial value (see tables on pp. 285-287, Div. II.), may form a much larger proportion of the bulk of the dung than in another.

Obviously, therefore, there must be many degrees of quality in farmyard dung,—a fact which farmers should keep carefully in view in considering how many tons of dung, and what supplementary manure, should be given to this field or that. Moreover, as we have seen, in pp. 501-513, Div. II., the original character of the dung may be greatly altered—improved or damaged—by the manner in which it is made, and treated generally. These considerations should never be lost sight of. One ton from a certain dung-heap may be worth two tons from another.

The information given on pp. 283-289, Div. II., as to the "manurial value" of foods, indicates how, and to what extent, the manurial value of dung may be affected by the food supplied to the animal. It has long been recognised that dung made by fattening stock is much more valuable than that made by store cattle, which are sparingly fed; yet, in practice, this fact does not always have due consideration.

What is said on pages 226-232, Div. I., as to manure in covered and open courts, should also be consulted here.

Manurial Value of Straw.—The straw of the cereal crops does not possess such high manurial value as is by many accorded to it. The constituents of fresh straw are for the most part insoluble, so that straw is of little use in the soil unless it is well rotted. Indeed, the principal value of straw in the making of manure is that it, in the first place, forms comfortable litter for the animals, and thereafter becomes a suitable vehicle for absorbing and holding in a manageable condition the solid and liquid excreta. From this it is apparent that the excessive use of straw as litter is imprudent and wasteful; for, while the bulk of the dung may be thereby greatly increased, there may be little more fertilising value than if one-third less litter had been supplied.

Composition of Dung.—From the foregoing it is of course obvious that the chemical composition of farmyard dung is liable to great variation. The following detailed analyses of samples of farmyard dung were made by Dr A. Voelcker.

Composition of *fresh* dung, composed of horse, cow, and pig dung, about fourteen days old:—

Water	66.17
*Soluble organic matter	2.48
Soluble inorganic matter	1.54
†Insoluble organic matter	25.76
Insoluble inorganic matter	4.05
	100.00

*Containing nitrogen	.149	
Equal to ammonia	.181	
†Containing nitrogen	.494	
Equal to ammonia	.599	
Total percentage of nitrogen		.643
Equal to ammonia		.780
Ammonia in a free state		.034
Do. in form of salts		.088

Composition of the whole ash:—

Soluble in water, 27.55 per cent.	Soluble silica	4.25
	Phosphate of lime	5.35
	Lime	1.10
	Magnesia	0.20
	Potash	10.26
	Soda	0.92
	Chloride of sodium	0.54
	Sulphuric acid	0.22
	Carbonic acid and loss	4.71

Insoluble in water, 72.45 per cent.	Soluble silica	17.34	
	Insoluble silicious matter	10.04	
	Phosphate of lime	...	
	Oxide of iron and alumina, with phosphates	8.47	
	containing phosphoric acid		(3.18)
	equal to bone-earth		(6.88)
	Lime	20.21	
	Magnesia	2.56	
	Potash	1.78	
	Soda	0.38	
	Chloride of sodium	...	
	Sulphuric acid	1.27	
	Carbonic acid and loss	10.40	

The composition of *rotten* dung, mixed horse, cow, and pig dung, six months old, dark brown, almost black in colour, well fermented and short, is as follows:—

Water		75.42
*Soluble organic matter		3.71
Soluble inorganic matter		1.47
†Insoluble organic matter		12.82
Insoluble inorganic matter		6.58
		100.00
*Containing nitrogen	.297	
Equal to ammonia	.360	
†Containing nitrogen	.309	
Equal to ammonia	.375	
Total amount of nitrogen		.606
Equal to ammonia		.735
Ammonia in a free state		.046
Do. in form of salts		.057

Composition of the whole ash:—

Soluble in water, 18.27 per cent.	Soluble silica	3.16	
	Phosphate of lime	4.75	
	Lime	1.44	
	Magnesia	0.59	
	Potash	5.58	
	Soda	0.29	
	Chloride of sodium	0.46	
	Sulphuric acid	0.72	
	Carbonic acid and loss	1.28	
Insoluble in water, 81.73 per cent.	Soluble silica	17.69	
	Insoluble silica	12.54	
	Phosphate of lime	...	
	Oxides of iron, alumina, with phosphates	11.76	
	containing phosphoric acid		(3.40)
	equal to bone-earth		(7.36)
	Lime	20.70	
	Magnesia	1.17	
	Potash	0.56	
	Soda	0.47	
	Chloride of sodium	...	
	Sulphuric acid	0.79	
	Carbonic acid and loss	16.05	
		100.00	

Fresh Dung. — The comparatively small proportion of soluble, organic, and mineral substances in fresh dung accounts for its slow action compared with rotten dung. Insoluble matters are very large —of organic matters, ten times as great as soluble; and of mineral matters, three times as great as soluble. Fresh dung contains a mere trace of free or volatile ammonia, and but a trifling quantity of ammoniacal salts. The amount of nitrogen in fresh dung is inconsiderable. It is gradually liberated as the dung progresses in putrefaction, and is contained in the portion insoluble in water. Hence little nitrogen exists in fresh dung in a state to be assimilated by plants. The principal constituent of soluble ash in quantity is potash 37.26 parts, equal to 54.7 parts of pure carbonate of potash, also silicate of potash; and in the insoluble ash, lime, and in the soluble, phosphate of lime, 19½ per cent. Chemically, farmyard dung is a universal manure, because it contains *all* the constituents of our cultivated crops; and it is a perfect manure, because its constituents are in that state of combination favourable for the luxuriant growth of our crops.

Fresh and Rotten Dung.—Fresh dung contains considerably more potash than rotten, as also more phosphate of lime. There is more nitrogen in rotten than in fresh dung; rotten dung has less insoluble organic matter, and contains more insoluble inorganic matters than fresh. On the whole, weight for weight, rotten dung is richer in soluble fertilising constituents than fresh, and contains more readily available nitrogen, and therefore produces a more immediate and powerful effect in vegetation. The preference evinced by farmers for rotten over fresh dung is thus sanctioned by chemistry.

Open and Covered Court Dung.—Farmyard dung, kept under roof for three months, was found to have suffered little change in organic and mineral constituents in comparison with fresh dung, and the soluble and insoluble portion of the ashes was almost identical. Rotten dung exposed to the air in cold weather loses little substance, but in warm weather the loss may be considerable—principally in the soluble constituents, nitrogen and ammoniacal salts rapidly becoming exhausted. Fresh

dung undergoes putrefaction rather than fermentation, the nature of which process consists in the gradual alteration of the original organic matters, and in the formation of new chemical compounds. Putrefaction is accompanied with evolution of heat; air and water are both requisite for putrefaction. If kept perfectly dry, organic substances remain unaltered for an indefinite period.

Fixing Ammonia.—Ammonia is generated in large quantities during the putrefaction of the nitrogenised constituents of dung. It is this free ammonia which is liable to be lost. Fortunately some natural provision is made for its conservation. The straw in course of putrefaction is, to a great extent, converted into humic and ulmic acids, which have a powerful affinity for ammonia, and which, therefore, to a certain extent, fix the ammonia as it is generated. These acids form, with potash, soda, and ammonia, a dark-coloured, very soluble compound. Hence the dark colour of the drainage of dung-heaps.

Dr Anderson on Dung.—The chemical remarks of Anderson on the analyses of Voelcker are worthy of attention by the farmer: "On comparing and examining these analyses, it appears that the differences are by no means great, although on the whole they tend to show, weight for weight, well-rotted dung is superior to fresh, *provided it has been properly treated.* Not only is the quantity of valuable matters existing in the soluble state materially increased, whereby the dung is enabled to act with greater rapidity, but, owing to evaporation and escape of carbonic acid, produced by the decomposition of organic substances, the proportion of those constituents which are most important to the plant is increased. This is particularly to be noticed in regard to the nitrogen, which has distinctly increased in all cases in which the dung has been kept for some time; and the practical importance of this observation is very great, because it has been commonly supposed that, during the process of putrefaction, ammonia is liable to escape into the air. It would appear, however, that there is but little risk of loss in this way, so long as the dung-heap is left undisturbed; and it is only when it is turned that any appreciable quantity of ammonia volatilises. It is different, however, with the action of rain, which soon removes by solution a considerable quantity of nitrogen contained in farmyard manure; and the deterioration must necessarily be conspicuous in rotten dung, which sometimes contains nearly half of its nitrogen in a soluble condition. . . . Well-made and well-preserved farmyard manure will generally be found to differ comparatively little in value; and when bought at the ordinary price, the purchaser is pretty sure to get full value for his money, and the specialties of its management are of comparatively little moment to him. But the case is very different when the person who uses the manure has also to manufacture it. Though the manure made in the ordinary manner may, weight for weight, be as valuable as at first, the loss during the period of preservation is usually very large, and it becomes extremely important to determine the mode in which it may be reduced to the minimum. In the production of farmyard manure of the highest quality, the object to be held in view is to retain, as effectually as possible, all the valuable constituents of the dung and urine. In the management of the dung-heap there are three things to be kept in view: first, to obtain a manure containing the largest amount of nitrogen; secondly, to convert that nitrogen more or less completely into ammonia; and, thirdly, to retain it effectually."[1]

Other analyses of dung show from 65 to 80 per cent of water, from 0.40 to 0.65 per cent of nitrogen, and ash (exclusive of earth and sand) from 2.50 to 3.00; the ash containing from 0.4 to 0.7 potash and from 0.2 to 0.4 phosphoric acid per cent.

Fertility in a Ton of Dung.—Even greater variations than these are to be met with in the analyses of farmyard dung. The manurial value of dung is governed by the amount it contains of nitrogen, potash, and phosphoric acid. The quantity of these in one ton may *range* as follows:—

	lb.
Nitrogen . .	8 to 16
Potash . .	8 to 17
Phosphoric acid .	2½ to 9

[1] Anderson's *Agric. Chem.*, 176-179.

A ton of first-class well-made farmyard dung, all kinds mixed, should contain the following, or thereby:—

	lb.
Nitrogen	12 to 14
Potash	11 to 15
Soluble salts of phosphoric acid (equal to soluble phosphate of superphosphate)	8 to 9
Insoluble phosphates (as in bones)	10 to 13

Produce of Dung per head of Stock.—The quantity of dung produced by a given number of stock will vary with the class of stock, the amount of food consumed, the quantity of litter supplied, and the amount of rain-water admitted amongst the dung. Each farm-horse will make about 12 tons of dung in a year—producing about three-fourths of its food in manure. In stalls or covered courts, full-grown feeding cattle will each produce from 10 to 12 tons of dung in the year, allowing, say, from 10 to 20 lb. of litter to each per day. In open yards the weight might be about 2 tons per head more. The solid excreta of an ox has been estimated at from 50 to 65 lb. daily, and liquid from 65 to 95 lb. daily. The above quantities of manure made by stock would thus be still greater if the whole of the urine were incorporated with the solid excreta and litter.

Fresh and Rotten Dung.—In reference to the effects produced by the rotting of farmyard dung, Dr A. Voelcker says:—

"Direct experiments have shown that 100 cwt. of fresh farmyard manure are reduced to 80 cwt. if allowed to lie till the straw is half-rotten; 100 cwt. of fresh farmyard manure are reduced to 60 cwt. if allowed to ferment until it becomes 'fat or cheesy'; 100 cwt. of fresh farmyard manure are reduced to 40–50 cwt. if completely decomposed.

"This loss not only affects the water and other less valuable constituents of farmyard manure, but also its most fertilising ingredient, nitrogen. Chemical analysis has shown that 100 cwt. of common farmyard manure contain about 40 lb. of nitrogen; and that during fermentation in the first period 5 lb. of nitrogen are dissipated in the form of the volatile ammonia; in the second, 10 lb.; in the third, 20 lb. Completely decomposed common manure has thus lost about *one-half* of its most valuable constituents.

"According to other experiments, the loss on the weight of fresh, common, mixed farmyard manure, at different periods, approximately, is as follows:—

"10 cwt. of dry food and straw yield—

	cwt.
Of recent dung	23 to 25
At the end of six weeks	21
After eight weeks	20
When half rotten	15 to 17
When fully rotten	10 to 13."

Character and Uses of Farmyard Dung.

A Complete Manure.—Farmyard manure contains all the elements necessary for plant-growth, and is therefore a *complete manure*. If applied in sufficient quantity, it will, without any extraneous aid, maintain fertility even under an intense system of cropping.

Mechanical Uses of Dung.—As a manure, dung is valuable, not only for its chemical but also for its mechanical properties. Referring to this point, Sir John Bennet Lawes says that by reason of its bulk and the quantity of organic matter it contains, it serves to render the soil more open and porous, and so enable it not only to retain more water in a favourable condition, but also to absorb and retain more of the valuable constituents of the manure, and so arrest the passage of them in solution into the drains. Further, by the gradual decomposition of the organic matter of the dung, the pores of the soil become filled with carbonic acid, which probably serves to retard the oxidation of the ammonia into the more soluble form of nitric acid, in which it would be more liable to be washed out and lost by drainage. From these facts, Sir John considers it will be readily understood how it is that dung is more lasting in its effects than the more active artificial manures.[1]

It is well known that, by repeated applications of farmyard dung, stiff clays have been rendered more friable. And its mechanical influence on such soils is more effective when the dung is applied in a rank state,—that is, before the straw it contains—or rather, the straw which contains the manure,—has become thoroughly rotten.

[1] *Jour. Roy. Agric. Soc. Eng.*, ii. 8, 1875.

Dung Heating Soil.—Then it is equally certain, though not so generally recognised, that a heavy dressing of rank dung benefits the soil by raising its temperature. "The temperature of the soil is affected by other causes than the sun's rays. Decaying vegetable matter is a source of heat, as evidenced by the high temperature arising from the fermentation of dung. Farmyard manure thus supplies heat to the soil from two different sources, while it helps to retain much valuable manurial ingredients, which, in a more purely mineral soil, would be washed away."[1]

Lasting Influence of Dung.—The great lasting influence or "staying power" of farmyard manure is an important factor in practical agriculture. For the full understanding of the extent, advantages, and risks of this enduring power and slow-acting characteristic of farmyard dung, it is necessary to refer the reader to the results of the Rothamsted investigations, as described by Mr Warington, under the heading of "Rothamsted Experiments" (pp. 135-169, Div. III.) See particularly what is said there as to the accumulation of fertility in soil heavily dressed with dung (pp. 153-167); as to the lower immediate efficiency of the nitrogen in dung, as compared with a corresponding amount of nitrogen supplied in ammonia salts or nitrate of soda (pp. 139-146); as to the loss of the nitrogen of dung in nitrates formed during autumn and winter, and washed away in drainage-water (pp. 154-168); and as to the loss of surplus nitrogen—that is, of available nitrogen not immediately assimilated by a growing crop—by evaporation in the form of nitrogen gas (pp. 166-168).

Similar results are shown in the Rothamsted barley experiments. For twenty years up to 1871, 14 tons of dung were applied every year to one plot for barley, and the average produce was 48¼ bushels. No further manure of any kind was applied to this plot, upon which barley was continued, with the result that the average yield for the next twelve years fell off by about one-third. It was estimated that of the 4000 lb. of nitrogen per acre supplied to the soil in the 14 tons of dung for twenty years, only about 14 or 15 per cent had been recovered in the increase of crop. From this it was calculated that if all the remaining 3400 lb. of nitrogen had been stored up in the soil, in a form as available as that which had already been used in the crop, this plot should have been able for 150 years to produce an average of 48 bushels of barley per acre per annum. Yet with the stopping of the annual dressing of dung, the crop showed a very marked decline.

How is this decline to be accounted for? There had, no doubt, been some loss of nitrogen in drainage, and some may have been volatilised. But, upon analysis, the soil was found to contain a great accumulation of nitrogen, as well as other constituents. This great accumulation of nitrogen and other constituents of the dung, if it had remained in the soil in a *sufficiently available* form, would have supplied the crop with all the food it could absorb for many years. Why, then, does this abundant residue give such a poor account of itself? In reference to this important question, Dr Gilbert remarks "that it is only the comparatively small proportion of the nitrogen of farmyard manure which is due to the liquid dejections of the animals that is in a readily and rapidly available condition; whilst that due to more or less digested matter passing in the fæces is more slowly available, and that in the litter remains a very long time inactive."

The potato experiments at Rothamsted afforded equally striking evidence of the slow recovery of the nitrogen supplied in dung. Fourteen tons of farmyard manure, applied every year for six years, yielded in potatoes only 6.4 per cent of its nitrogen; while in the next six years, the same crop every year, without any further dressing of manure, recovered from the residue only 5.2 per cent more—that is, only 11.6 per cent in the course of the twelve years. In other words, at the end of the twelve years there was still about 88 per cent of nitrogen supplied in the dung unrecovered by the crop.

An Old Custom Questioned.—All these are considerations which—although subject to modifications under ordinary farm practice—should have studious attention from farmers. They unquestion-

[1] *Mark Lane Express*, 1889, p. 412.

ably suggest that in the past farmers have placed rather too much faith in farmyard manure—that the old custom of manuring only once in a rotation—of applying with the root-crop a heavy dressing of dung, in the belief that what of the manure the roots do not appropriate will remain in the soil and be available for the use of the succeeding crops—may, in certain circumstances, be found to be seriously mistaken.

Loss of Residual Manure.—The unused portions of the manure unfortunately do not, in their entirety or nearly so, remain in the soil available for future crops. Much of this residue—of the most valuable portion of it too—is now found, under certain circumstances, to escape through channels which were formerly unsuspected as means of loss. The discovery of the great loss of excess or residual nitrogen by the washing away of nitrates in drainage-water, and by evaporation as nitrogen gas, throws new light upon the theory and practice of manuring, which farmers cannot afford to disregard.

Soil an Unreliable Custodian of Manure.—In times past we have placed too much faith in the soil as the custodian of costly manure. While nourishing a growing crop, the soil is commendably faithful to its trust, and does not then readily part with its available plant-food, except to the crop itself. But the moment the crop is removed, the soil loses retentive power, and if the conditions favourable to the washing away or volatilising of nitrogen are present, loss of residual nitrogen is liable to set in. Moreover, results obtained at Rothamsted seem to suggest the question whether some portion of the nitrogen which accumulates in the soil may not, in certain circumstances, undergo some sort of reversion by which it is rendered more slowly instead of more readily available to the crops.

Superiority of Dung Questioned.—Now nitrogen is the most costly of all the elements of manure. It is therefore obviously desirable that it should not only be drawn from the cheapest sources, but should also be supplied to the soil so as to guard as far as possible against any portions of it being lost in the manner just described. At first thought, one might say that the best plan would thus be to apply nitrogen in a readily available form, just when it is required by the crop, and only in such quantity as may supply the wants of that particular crop. This is, no doubt, sound enough theoretically, and may often be carried into practice with the best possible results.

But such a course will not, as a rule, be practicable. It would practically exclude the use of farmyard manure; and while it would be unwise to overlook or disregard the important results obtained under certain conditions at Rothamsted, it would be a still more serious error now to hastily jump to the other extreme, and unreasonably depreciate or discredit the great value of the fertilising materials in the solid and liquid excreta of farm animals.

Practical Conclusions.—The practical points to be kept in view are, that from the investigations as to the behaviour of nitrogen in the soil, it is seen that the enduring character of farmyard manure is not an unmixed advantage to the rent-paying farmer; that the excess nitrogen accumulated in the soil by heavy dressings of farmyard manure is, in certain circumstances, liable to serious losses by drainage and evaporation, and cannot, therefore, in all cases be to the *full extent* depended upon for the nourishment of future crops; that, therefore, the practice of so entirely or mainly trusting to heavy dressings of dung at long intervals for the production of profitable crops is neither reliable nor economical; and that the loss of nitrates from land which is rich in residual nitrogen, may be reduced to a minimum by having the soil covered with vegetation throughout the entire year, or in cold northern districts by having it bare only in the winter months when the temperature is usually too low for the formation of nitrates to proceed in the soil.

Vegetation Preventing the Loss of Nitrates.—For the last-named object many farmers, especially in England, sow some forage crop, perhaps rye, soon after the removal of a cereal crop. This not only engages the attention of unused nitrogen, thus preventing the washing away of nitrates, but most likely affords a useful feed to sheep in the course of the winter, and likewise further en-

riches the soil when ploughed down in spring.

Cold Weather and Loss of Nitrogen.—The above safeguard, to be sure, cannot be provided in the cold regions of the north, but then there is, fortunately, much less necessity for it there. It is in the form of nitrates in which nitrogen is washed away in drains. Nitrogen is transformed into nitrates by the operations of myriads of living atoms, commonly called *bacteria*. In very cold weather, with the temperature at or near to freezing-point, these wonderful little atoms of life seem, with commendable beneficence, to relapse into idleness; so that at this cold season of the year the northern farmers may with tolerable, if not complete, immunity from loss of nitrogen, till their land and leave it exposed to the action of frost, as has been their wont from time immemorial.

Making Dung or Selling Crops.—We are not to discuss fully the question as to whether farmers should endeavour to make as much dung as possible, or should sell produce and purchase artificial manures. Local circumstances vary so much that the conditions which determine the best system in one case may not apply equally to another. Much will depend on the locality and character of the holding, and the tastes of the tenant—whether favourable to the breeding and feeding of stock, or the growing and selling of crops; also upon the fluctuations of market prices—especially as to the relative prices of beef, feeding-stuffs, and litter, on the one hand, and of artificial manures on the other.

Farmers now less Dependent on Dung.—With the abundance of excellent artificial manure in the market, and with the great advance that has been made in the investigation and elucidation of the principles which govern economical and successful manuring, farmers are now much less dependent upon farmyard manure than in former times. They have no need any longer to cousume their crops on the farm for the sake of providing manure with which to restore fertility to the soil. This may now be accomplished cheaply and efficiently by the use of other manurial substances, of which exhaustless supplies are at hand. It is unquestionable, therefore, that dung, as a source of plant-food, has been depreciated in its relative intrinsic worth, and in its importance as a factor in agriculture; and that it should not count for so much on the credit side of the feeding account as it has often done in times gone by.

Dung not likely to Diminish in Production.—But farmyard manure is a necessary accompaniment of the rearing and feeding of stock, and there is little likelihood that, with the growing importance of the live-stock industry, there will be any falling off in the production of farmyard manure. In all probability it will be of a more concentrated character than in former times. Straw is now being turned to better purpose as food for stock, or in other ways than as litter for cattle. The animals may therefore be littered with smaller quantities of straw, or with other substances less bulky, such as peat-moss litter. But while the dung may thus be more concentrated, and less bulky per head of stock than it would be with freer use of straw as litter, it is not likely that the amount of fertilisers annually available in the form of farmyard manure for application to the soil will be less in the future than it has been in the past.

A Word for Dung.—Although farmyard manure is not likely to lose its hold upon the affections of British farmers, it nevertheless seems desirable to remind the reader that in considering the practical lessons to be drawn from the Rothamsted experiments with dung and other manures, it should be kept in view that these experiments were not framed as a guide to farmers in pursuing the ordinary routine of farm practice. The scientific conclusions arrived at are undeniably of great value to farmers, but it would be imprudent to attach to them a significance which they were not intended to and do not possess. If the course of cropping and systems of tillage pursued at Rothamsted had been similar to those observed in the rotations followed throughout the country, the dung would, in all probability, have given a much better account of itself. In particular, it is probable that the accumulation of inert nitrogen would have been roused to greater activity and usefulness, so that under a rotation of crops, with the

thorough tillage necessary for roots, the influence of the residue of the dung would have been more marked than it has been upon the continuous growth of the same crops on the same respective plots.

Professor Wrightson on Dung.—Professor Wrightson is a strong advocate of the superiority of farmyard dung over artificial manures. As to the reasons why he thinks farmyard dung should hold a strong position in the estimation of the British farmer he says:—

"The first reason, no doubt, is what has been already advanced—the general composition of dung. A great many science students stop here. When they are asked why farmyard manure is a more potent and more valuable manure than many artificial fertilisers, they say it is because of its general composition. But there are a good many other reasons beside, one of which is, no doubt, its effect upon the mechanical condition of the soil—a subject which we have already had before us, and which it is therefore not necessary to further enlarge upon. Then, in the third place, there is the reaction of the carbonic acid gas which is evolved from farmyard dung, upon the mineral matter in the soil. I do not doubt in the least that it digests the soil.

"I do not doubt that Jethro Tull was perfectly right when he said farmyard manure prepared plant-food. No doubt it does; it is the source of carbonic acid gas, and we know that that gas in watery solution reacts on the mineral matter in the soil with great effect.

"Now take another reason. Farmyard dung is rich in nitrogen; that alone places it on a superior basis to most artificial manures. It is rich in nitrogen in a state of organic combination, from which it is liberated slowly by the process of decay, that liberation of nitrogen being known as nitrification. Performed under favourable temperatures, with access of air, and no doubt also assisted by the agency of certain bacteria which work in the soil and produce the peculiar fermentation necessary, this nitrification of farmyard manure in the soil is arrested at freezing-point. It proceeds very slowly at low temperatures, and with accelerated speed at higher temperatures. Especially does it take place freely during the summer months, when vegetation is most luxuriant.

"Hence farmyard manure subjected to gradual decay yields up its materials, especially nitrogen oxidised into nitrates, at that period of the year when they are wanted. It is worth notice that the same forces which liberate nitrogen must also liberate the mineral and other constituents of farmyard dung, gradually and as required."[1]

ARTIFICIAL AND SPECIAL MANURES.

In addition to farmyard manure there are the various artificial or special manures, which supply one or more of the ingredients necessary for the growth of plants.

Classification.—These are classified in accordance with the proportion of the more valuable or abundant constituents present in them, and they are accordingly divided into the following groups: nitrogenous, phosphatic, potassic, calcareous manures. The liming of land will be dealt with in a subsequent division of the work.

Peruvian Guano.

The chief of the nitrogenous manures is guano in its various forms.

In the year 1839, some twenty barrels of a red or light-brown substance were imported into Liverpool from one of the islands which lie adjacent to the Peruvian coast. The substance had been in use as a manure amongst the natives of Peru for many centuries. It became known as guano, a term which takes its origin from the Peruvian word "huana," dung or manure, which consists of the accumulated droppings of sea-fowls during long periods of time.

As the temperature stands very high in those regions (lying between 13° and 21° south latitude), these bird-droppings soon dry; and as the climate is almost a rainless one, much of the soluble ingredients are preserved.

The resulting manure is a complex one, possessing a composition similar to farmyard manure. After experiment, and when the merits of the guano were

[1] *Principles of Agric. Prac.*, 152.

brought home to the mind of the farmer, the demand for it rose very quickly.

We can form some idea of the estimation in which this manure was held by the Peruvians from the proverb, "Huano, though no saint, works many miracles;" and from the fact that, under the government of the Incas, the killing of birds which frequented the islets in which guano deposits were formed, was made a capital offence.

When the exportation attained considerable proportions, the Peruvian Government, by exercising its lordship of the soil, created a monopoly of the sale of guano, which was sold at so much per ton irrespective of quality. The first contract made by British merchants was in 1840 or 1841. They made it a condition of the contract that for a period of four years they would have the exclusive right to export from the island of "Chincha" 20,000 tons of guano yearly.

The increasing demand and the monopoly, which raised the price of guano above its real value, together with the fact of the richer deposits becoming exhausted, led to guano being sold on analysis. This arrangement is still in existence; and as a consequence, it is customary for sellers to attempt to sell cargoes upon "official analysis."

From the year 1850 to 1870 there was a large increase in the demand for guano, as many as 200,000 tons having been imported in a single season. The quality of the Peruvian deposits was yearly deteriorating, and accordingly other coasts were explored, resulting in the discovery of deposits in the African coast which lies between these latitudes. Ichaboe was the richest, and Mejillones the poorest. These two guanos are fair representatives of what is known in the trade as high-class and low-class guanos. The one contains a large percentage of ammonia and a low percentage of phosphates; the other a high percentage of phosphates and a low percentage of ammonia or none at all.

Composition of Guanos.—The following may be considered as an average analysis of these guanos, to which is added the analysis of "Pabellon," which is now offered in the market, and which will be seen to be very much lower than the others in quality:—

	Peruvian.	Ichaboe.	Mejillones.	"Pabellon."
Phosphates . . .	24.00	10.86	71.16	32.38
Potash . . .	2.00	2.00	2.00	2.10
Ammonia . . .	17.00	13.00	.75	9.39

These analyses show Peruvian, Ichaboe, and Pabellon to be rich in nitrogen, and are therefore called nitrogenous or high-class guano. To these may be added "Punta de Lobos," "Huanillos," which are somewhat richer in phosphates and poorer in ammonia.

Mejillones is purely phosphatic, and is a low-class guano. The latter term, however, embraces guanos which contain anything under 4 per cent ammonia and over 40 per cent phosphates. The absence of ammonia is due to these guanos being deposited in climates where frequent and heavy rains occur. These heavy rains supply the moisture necessary to set up fermentation in the guano, and they wash away the soluble salts and ammonia which are the products of this fermentation.

Fish Guano.

Formerly there was great loss of fish-offal. In many cases no attempt was made to utilise this offal, which, besides the heads and entrails of all the larger fish, and the cleanings of the herring-curing stations, often included large quantities of entire herring which the curers were unable to manipulate. Neighbouring farmers bought large portions of this offal; but frequently they could not use up the supplies, so that many boat-loads of fish were emptied into the sea as being the only means of getting rid of the material.

Such excessive waste could not long continue in the light of the nineteenth century. At length, at the various fishing-stations, factories were erected in which the offal is submitted to the action of steam at a high pressure, and afterwards it passes through the hydraulic press, by which means the greater portion of the oil is extracted. The whole mass is next passed through the disintegrator, and thus is produced the article known as *fish guano*.

Composition of Fish Guano.—The composition of fish guano varies from 8 to 12 per cent of ammonia, and from 15 to 30 per cent of phosphates. The fish guano in the market seldom contains more than about 9 or 10 per cent of ammonia and 16 to 20 per cent of phosphates. But there is also present from 3 to 6 or 8 per cent of oil, which detracts from the value of this manure, as the oil retards the dissolving of the elements of plant nutrition which the fish guano contains.

Frey Bentos Guano.

In the manufacture of Liebig's extract of meat there is a large residue of flesh, bone, and muscle. These substances are mixed together, dried, and ground, the product being a flesh guano, if we may so term it. In other instances a large supply is obtained from diseased meat and animal refuse of all kinds.

Composition. — The composition of flesh guano varies from about 8 to 13 per cent ammonia, and from about 10 to 20 per cent phosphates.

Dissolved Guanos.

The unequal character of natural guano in recent years has led to its being treated (some would say spoiled) with sulphuric acid, and its composition being otherwise altered by the introduction of ammonia from sulphate of ammonia, dried blood, or other organic source. This process dissolves the phosphates and organic matter, making these more soluble, and the nitrogenous matter raises the percentage of ammonia, so that an active manure is the result. This commodity is known as Dissolved Peruvian Guano.

Composition. — Dissolved Peruvian guano is usually in good mechanical condition. It seldom contains more than 8 per cent ammonia, and perhaps from 20 to 23 per cent soluble phosphates, and 3 or 4 per cent insoluble phosphates.

Dried Blood, &c.

Dried blood, horn-dust, shoddy, and other waste products from the shambles or factory, may all be treated as insoluble nitrogenous substances, coming into action slowly. They contain from 5 to 16 per cent of ammonia, but no other fertilising matter of much importance. They are used principally in the manufacture of dissolved and compound manures, and contribute to the percentage of ammonia in these.

Nitrate of Soda.

Nitrate of soda, otherwise known as Chili saltpetre or cubic nitre, is the most abundant and best known of these salts.

This salt is a natural product of the soil in tropical climates, and as to its formation, several theories, less or more different, are entertained. A full description or discussion of these theories need not be attempted here. Some hold that it is made from the action of water, impregnated with soda salts upon guano. Others attribute its formation to sea-weeds, which, by their decay, have given rise to nitrate of lime, which reacted upon sulphate of soda, the products being nitrate of soda and sulphate of lime. It is supposed that these beds were at one time isolated lagoons—isolated by volcanic action. The sea-water on its evaporation would leave a large salt deposit, thus furnishing the source of the large quantity of soda salts found in these nitrate beds. The lime would, according to this sea-weed theory, be supplied by sea-shells, &c.

The chief sources of supply are Chili, Peru, and Bolivia, where it occurs in beds varying from 10 inches to 16 feet in depth, sometimes quite near the surface, but generally covered by several feet of a layer known as "Costra." The regions in which nitrate of soda is found are quite destitute of vegetation, and there is often a period of several years without rain. These beds lie in the Pampas known as "Los Salinas," which is over 40 leagues in extent, and literally covered with beds of nitrate of soda.

The supply may be looked upon as almost inexhaustible. In its native state it is mixed with impurities, notably chloride of sodium (common salt) and sulphate of potash, soda, lime, &c. But before exportation it undergoes a process of refining which renders it comparatively pure, 5 per cent being about the amount of impurities remaining in it.

Nitrate of soda, when first introduced

as an artificial manure, came into great repute amongst farmers as a fertiliser. Its high price, however, and the lack of correct views as to its action and unsound mode of application, brought it into such ill favour that on some estates its use as a manure was in certain circumstances prohibited.

In recent years, however, with more enlightened views as to its character and action, a steady increase in the demand has arisen. Indeed this salt is to a large extent, as a source of nitrogen, taking the place of that now more variable commodity Peruvian guano. We find that in the year 1880, 50,000 tons of nitrate of soda were imported, while in 1887 the imports of it exceeded 110,000 tons. It is likely, indeed, that the output of nitrate of soda will soon reach a million tons annually. At the present time nitrate of soda is the cheapest source of nitrogen in the market, and has become the most important of the artificial manures. It usually consists of 95 per cent pure nitrate of soda, which is equal to about 19 per cent of ammonia.

Nitrate of Potash.

This salt is much more valuable than nitrate of soda, both commercially and from an agricultural standpoint. Nitrate of soda supplies only one of the ingredients of plant-food, whilst nitrate of potash provides two—nitrogen and potash,—and is a valuable manure where applied to soils poor in clay and where no farmyard manure has been applied.

Nitrate of potash has been imported from India for many years, it being the nitre or saltpetre of commerce. The source of this Indian nitrate of potash is believed to be human urine which had at some time been poured upon the soil, these nitre-beds being found near the sites of ancient cities. Until lately its high price prevented farmers from using it as a manure.

It is, however, produced by artificial means, which is of interest to farmers, as seen in the nitre-beds or saltpetre plantations which originated in France during the last century so as to obtain a supply of nitre for the manufacture of gunpowder. The manner in which this nitre is produced ought to be studied by every farmer, as he is in many instances, perhaps unknown to himself, producing this salt in the soil of his farm.

Forming Nitre-beds.—A brief description of how nitre-beds are formed will place the matter clearly before our readers. A quantity of fertile loam is procured, and with it is incorporated highly nitrogenous organic matter—such as blood, flesh, liquid manure, stable manure, &c. To this is added chalk or old mortar-lime, and the whole mass turned over once or twice, after which the soil is washed and the water evaporated, when the residue is found to be crystals of nitrate of potash.

The chemical changes which here take place are as follows: The decay of organic matter is hastened by the lime, and produces nitric acid. Ammonia is produced, and becoming oxidised it is converted into nitric acid, which combines with the lime in the first instance, and afterwards with the liberated potash, and thus is evolved the nitrate of potash.

Nitrification.

Theory of Nitrification.—The latest theory in connection with nitrification is that organic matter, when it is allowed free contact with the air and moisture within certain ranges of temperature, undergoes changes which break it up into simple bodies. This result is produced by the presence of myriads of minute organisms termed "bacteria"—the *Micrococcus nitrificans* of Van Teighern, and other forms of bacteria. These living bodies feed upon the nitrogenous matter, and increase in numbers at a rate of which we can have but little conception. Every fertile soil, therefore, becomes the home of countless millions of these living organisms which carry on the work of nitrification, so that, as Professor Cohn tersely puts it, "Putrefaction is the concomitant not of death but of life."

Conditions which favour Nitrification.—The conditions necessary for the life and development of the nitrification ferment are,—(*a*) temperature above 40° Fahrenheit and under 130° Fahrenheit—most favourable temperature, 100° Fahrenheit, development at that temperature being as great in a

few days as in months at a lower; (*b*) a certain amount of moisture; (*c*) presence of organic matter, mineral constituents of plant-food, carbonate of lime, and a plentiful supply of oxygen. Any excess of putrefying organic matter in a soil is against nitrification. It is found to be most active near the surface of the soil; it is not found much below 18 inches. Strong sunlight is not so favourable as darkness. The bacteria are easily killed by poisons, such as ferrous sulphate of iron, coal-tar, and sulphuretted hydrogen.

Hellriegel's Theory.—A still further development in the theory of the formation of nitric acid has been recently announced by a Continental *savant* named Hellriegel, who by careful observation, and a series of experiments on the manner of growth of legumes or pod-plants, has arrived at the conclusion that the excrescences or warts found on the roots of these are largely composed of bacteria, or fungoid matter, which have the power of changing the inert nitrogen of the atmosphere into the active form, as seen in nitrates or ammonia.

There appears to be a wide difference between the organisms of this order and those present where organic matter is in process of decay, as the latter can work only upon organic nitrogen, and break it up into simpler forms. It would be unsafe as yet to draw definite conclusions; but if this discovery is confirmed by further research, there can be no doubt it will lead to a considerable change in the system of cropping and manuring. The preceding will, at all events, serve to suggest the reason why a big crop of wheat generally follows a heavy crop of clover.

Sulphate of Ammonia.

Until recently, the chief source from which sulphate of ammonia was obtained was a by-product from the distillation of coal in the manufacture of gas. The ammonia set free is absorbed in water at a low temperature, which, on being heated by steam, gives off the ammonia, which is received in vessels containing sulphuric acid. These enter into combination, and sulphate of ammonia is the result. Pure samples contain from 22 to 25 per cent of ammonia. Another source of supply, which appears to be almost without limit, is obtained in the manufacture of pig-iron into steel, but perhaps the largest source of sulphate of ammonia is that obtained by the conversion of shale into paraffin-oil. The production has been largely increased by, if it has not been altogether due to, the introduction of the retort, invented by Young and Beilby, by the oil companies into their works. The process by which the sulphate is produced is similar to that carried out at the gas-works.

The preceding are the chief nitrogenous manures which are at present marketable commodities. Other substances might be mentioned, but they are either too expensive for use as manures, or contain their organic matter in such insoluble compounds as to be practically worthless.

Characteristics of Nitrogenous Manures.

There are a few points in connection with manures which should be carefully considered by farmers, so that they may be guided to a wise selection of manures to suit their varied circumstances as to soil, climate, and crop.

Essential Points.—It should in particular be borne in mind, (1) that the solubility of a manure depends on the minute division of its parts; (2) that the greater the solubility, the quicker its action; (3) that the shorter the time a crop occupies the ground, the more abundant and the more soluble must be the manure; and (4) that the rate of the growth of a crop ought to indicate the kind of manure, and the best state in which to apply it.

If these points are kept in view, the classification of manures in relation to their activity, and their action on the crop and in the soil, will be comparatively easy.

Slow and Active Manures.—A manure may, however, be perfectly soluble and yet not be available to the plant. It depends on the form in which its elements are combined whether the plant will absorb it or not.

For instance, nitrate of soda and sulphate of ammonia are equally soluble salts, but both are not alike available for plant-food. Nitrate being a com-

pound of nitric acid and an alkaline base, is readily absorbed and elaborated into the tissues of the plant; whilst, at any rate to most plants, sulphate of ammonia is not available until the ammonia absorbs oxygen, and is converted into nitric acid. The latter, therefore, does not come into action so quickly, and ought to be applied to the land before the plant is ready to absorb it. Nitrate of soda, on the other hand, is most economically applied after the plant has developed its leaf-surface to a greater or less extent.

Assimilation of Ammonia by Plants.—It is considered by some to be too sweeping an assertion to say that ammonia is not in any case available to plants until it is converted into nitric acid. It is admitted that most plants assimilate their nitrogen in the form of nitrates; but that some plants, more especially at certain periods of growth, have the power of assimilating their nitrogen in the form of ammonia would seem to be indicated by certain experiments by Lehmann. It is pretty generally admitted that the leaves of plants have the power of absorbing carbonate of ammonia from the air.

Action of Nitrate of Soda.—Nitrate of soda, as will be seen further on, is feebly retained by the soil, and should therefore be applied only to supply the wants of the crop then growing. The surplus will find its way to the subsoil, and may escape in the drainage-water. It exhausts the soil more quickly than any other manure, if the soil is unaided by the application of other manures. The reason of this is, that its action in the first instance tends to increase the leaf-surface of crops, which therefore make larger demands upon the soluble constituents of the soil, resulting in a heavier yield per acre. But if care is taken to have the soil sufficiently furnished with the other elements of plant-food, this exhausting influence of the nitrate may be effectually counteracted.

The turnips and other roots produced from nitrate of soda are light in weight, porous and inferior in feeding qualities, and are apt to decay when touched by frost. In a dry season, nitrate of soda gives better results than sulphate of ammonia, and increases the produce of straw, but produces light grain. When applied to grass, nitrate of soda checks the growth of clover, which, it would seem, dislikes the presence of an acid, although the acid is of great benefit to plants of a different order.

Action of Sulphate of Ammonia.—Sulphate of ammonia being slower in its action—see above—gives more time especially for roots to grow, and on this account the roots grown on land to which sulphate of ammonia is applied are often denser and heavier, and of better feeding qualities than where nitrate of soda has been applied. This is true, although the *direct* action of the two is identical, and chiefly confined to the shaws, the roots being injured in keeping and feeding qualities by an excessive dressing of either.

It has been shown by experiment that sulphate of ammonia improves grass both in quantity and quality.

Nitrate of Soda and Sulphate of Ammonia Compared.—We have seen that sulphate of ammonia contains considerably more nitrogen than nitrate of soda, the most general proportion being about 13 in the former to 10 in the latter. Experience, however, has shown that the nitrogen in the nitrate of soda is the more effective, producing at Rothamsted and Woburn about 14 per cent more barley, and from about 5 to 25 per cent more wheat, than sulphate of ammonia; while, when applied with potash salts and phosphates to grass-hay and potatoes, similar results were obtained. When applied alone, the nitrate of soda was far superior to the sulphate of ammonia. With mangels the evidence in favour of nitrate of soda has been still more striking. It may thus be taken as fully established, that although sulphate of ammonia may contain nearly one-third more nitrogen than nitrate of soda, it is not, as a rule, worth to the farmer more than from one-tenth to one-eighth more money per ton.

Guano, when of fairly good quality, gives better results than either nitrate of soda or sulphate of ammonia.

Excessive Nitrogenous Applications Injurious.—The excessive application of nitrogenous manure tends to increase the percentage of nitrogen and diminish that of phosphoric acid in the composition of plants. This fact leads to wide

issues; for the relation between the soil and plant is in no way closer than that between plants and animals. From this cause we have weed and diabetes in horses, and, where phosphates are deficient, rickets, rotten teeth, and late dentition, &c., &c.

Nitrogenous Salts are not suited for grain crops when applied alone, as the tendency is to produce straw at the expense of the grain. But when these are mixed with phosphates, excellent results are obtained.

Slow Manures for Slow Crops.—The period of time during which the crop occupies the ground has a considerable influence upon the economical use of soluble manures. Wheat takes often seven to nine months to mature, and during that period will have plenty of time to use up the soil constituents which are slowly soluble. Barley, on the other hand, is often harvested in four months or less; so that this cereal, being a shallow-rooted plant, will require readily soluble manure in greater abundance. For this reason, top-dressing once or twice with any of the more soluble nitrogenous manures, mixed with superphosphates, would give the best results; for it must be kept in view that crops can take up nitrates only when soluble phosphates and potash are present.

Action of Guano.—Guano is both a quick and a slow acting manure. The ammonia present in guano is to the extent of one-third or more in the form of salts which are readily soluble; the other portion is in the form of compounds more or less soluble. Its phosphates are of secondary consideration; but when guano of good quality can be obtained, it is undoubtedly the best manure in the hands of the farmer—that is, next to farmyard manure. Its use has now become limited by its high price and very variable composition.

Horn, Dried Blood, Shoddy, Woolwaste, &c., are very slowly acting manures, and are, in consequence, more fitted for pasture-land than for quick-growing crops. But in a dry season they may prove as effective on the root crops as the more soluble forms. They are used chiefly to fortify dissolved manures.

Power of Soils to retain Manures.—In connection with the more soluble manures, one should not overlook the fact that some soils have a greater power of retaining manures than others, and that some manures part with one or more of their elements more readily than others. The power of a soil to retain manure was at one time thought to be a mere physical property pertaining to it, but later research has modified that opinion. Mr Way, in the *Journal of the Royal Agricultural Society of England*, clearly proves by experiment, that when solutions of the various salts are filtered through a layer of earth, and the solution, after filtration, is analysed, it is found to have lost all or nearly all the substances which it held in solution—it being the base rather than the acid which the soil had the power of retaining. This affinity is greater in some soils than in others, the following being the order: arable soil—clay, peaty, calcareous, sandy. It has also been found that the soil has a greater power of retaining some manures than others, the following being the order, those having the greater affinity being placed first: ammonia, potash, magnesia, lime, soda.

In explanation of this, Mr Way advances the following theory: In soils there are double silicates of lime and alumina. If potash be brought into contact with this double silicate, it replaces the lime; sulphate of lime and the double silicate of potash and alumina are produced. Silicate of alumina combines readily with ammonia, and least so with soda, &c.

Others, again, maintain that the oxide of iron, which is abundantly present in most soils, absorbs the ammonia. Mr Warington also finds that this oxide acts upon superphosphates. The soluble phosphoric acid may also be retained by recombining with lime and forming a slowly soluble salt.

Conserving Manures in Soils.—All agree, however, that the soil has little or *no power of retaining nitrates* in any combination. We must therefore look to some other means to preserve this valuable manure. The growth of catch crops has been recommended for this purpose. But this is impracticable in many instances, such as in ploughed land preparatory to the turnip crop. The work of the farm must go on in a regu-

lar manner, and the leaving of the fallow unploughed until spring would throw the work into confusion. Where the land can be kept under crop of any kind this should certainly be done, for the nitrates will be preserved by being absorbed by the roots and elaborated into the tissues of the plants as albumen.

It seems, however, that in this as well as in many operations connected with agriculture, where the farmer fails nature steps in and provides a remedy. This may be understood when we are aware that nitrification proceeds in exact proportion to the rise or fall of temperature, being at a minimum during winter, and ceasing entirely about freezing-point. We thus see that, during the season of least growth, nitrates are not produced, or produced only in small quantity; but as the temperature rises, and growth begins, then the bacteria resume operations, increasing in their productive powers until they reach the maximum during summer when the heat is greatest, and at the period of the greatest growth, and when nitrogen is most largely required for the further development of the plants.

Action of Nitrogen greatest on Young Plants.—We learn from experiments conducted by Arendt that the presence of albuminoids, which are largely composed of nitrogen, is greatest during the first period of the growth of plants, and becomes a gradually diminishing quantity until it nearly reaches maturity. The beneficial action of a soluble form of nitrogen, such as in nitrate of soda, may be understood from this, especially when applied to young grass or corn crops when they come into braird.

Phosphatic Manures.

Bones.—The use of bones as a source of phosphoric acid and nitrogen for the growth of crops, began long before the underlying principles of manuring were understood. The reason why an increase of crops should follow an application of bones was consequently the subject of many unsound theories.

Early use of Bone-manure.—The first authentic account we have of the use of bones in this country tells of their application in many parts of Yorkshire. Soon after they were applied to the exhausted pastures of Cheshire, the farmers of the latter county would seem to have fully appreciated the beneficial action of bones. Their active system of grazing with dairy cattle had greatly exhausted the phosphates of the soil, and the effect which followed a liberal dressing with bones was simply marvellous. Indeed the pastures to which they had been applied very soon increased in value by 30s. per acre.

Fame of Bone-manure.—As would be expected, the story of this wonderful result rapidly attained notoriety, and led to an extended use of bones as manure in these districts. The small home-supply of bones soon became exhausted, and the importation of bones from Germany and Northern Europe speedily developed into a regular trade, of which Hull was the chief centre.

The bone-trade of Hull now became a leading factor in the agricultural world, and the benefits which arose to all classes in the community may be summed up in the proverb, "One ton of German bone-dust saves the importation of ten tons of German corn."

Benefits from the use of Bone-manures. — But a direct increase in production was not the only benefit resulting from the use of bones as manure. The use of bone-manure played a leading part in the extension of turnip-culture, and in the consequent change of the whole system of farming formerly practised—changes which have led not only to a large increase in the production of food, but gave rise to that spirit of inquiry which has evolved and placed within our reach the mass of valuable information embraced in the term "Agricultural Chemistry."

Forms of Bone-manure.—Bones have been applied to the soil in many forms and conditions — raw or green, boiled, burned, broken, bruised, ground, fermented, and dissolved.

Raw, Broken, and Bruised Bones.—Raw bones, when dried so as to lose no more weight, are found to be made up on an average of 28 per cent organic matter and 72 per cent of inorganic matter or bone-earths. The presence of these is determined as to quantity by the kind of animal, its age, and the state of preservation of the bone.

Organic Matter in Bones.—The or-

ganic matter is almost entirely composed of ossein or cartilage. This substance is very rich in nitrogen, which yields on an average 22 per cent of ammonia. It is not, however, present in all bones in the same proportion. In young growing animals the cartilage is present in greater proportion than in an aged one, as the bones of the latter are composed largely of bone-earth, and are in consequence much more brittle, and when broken in a live animal take a much longer time to mend. Bones, again, are often collected from the plains of Russia and various parts of America, where they have been so long lying exposed to atmospheric influences, that it is found much if not all of the cartilage has disappeared. It has also to be considered that the manufactures of soap, glue, and gelatine often abstract a part of this substance along with fatty matter which adheres to fresh bones. It may therefore be accepted as a rule applicable to this as well as to all phosphatic manures which have not been adulterated, that the higher the percentage of ammonia, the lower the percentage of phosphates; and conversely, a high rate of phosphates means a low rate of ammonia.

Preparing Bone-manure.—When bones were first used, they were simply chopped into pieces or broken by hammers. The advantage of their being broken was soon apparent, and mills were erected at nearly all the ports at which cargoes of foreign bones arrived. Steam-power was first employed in breaking bones by Mr Anderson of Dundee in 1829, his machinery preparing the bones in the form of ½-inch, ¼-inch, and dust.

For some time farmers seemed to be satisfied with these sizes, as they considered that grinding the bones smaller detracted from their beneficial and lasting effect. The more observant, however, by watching the progress of their crops, noticed that the bone-dust came more quickly into action, and that it was mainly due to impurities that dust was not in favour. The dust being the small particles which passed through the riddles of the mills, would contain all the sand and earthy matter which would find a lodgment in the hollow parts of the bone; and much of the old bones which had lost part of their organic matter would also largely enter into the composition of this dust. Hence their inferior quality.

Fineness of Division appreciated.—The requirements of the turnip crop, however, increased the demand for quickly acting manure, so that farmers began to find out that the smaller the division the more soluble the manure. Thus bone-meal came into use, and has ever since remained the favourite form in which to apply insoluble phosphates to the soil.

Fermented Bones.—Before Liebig's discovery of dissolving bones with acid, various methods were tried to increase the solubility of bones, fermentation being one of many. It consists of mixing the bones with earth and saturating the mass with liquid manure, and allowing the heap to remain for a week or two before using. Some farmers in the present day ferment their bone-meal by throwing it into a heap after mixing it with water. In about a week the heat of the fermentation is at its greatest height, after which the heap will decrease in bulk and change in colour, the latter being due to the presence of insects and germ-life, which attack the organic portion of the bone and decompose it. There can be no doubt this process hastens the solubility of bones.

Bone-ash and Bone-flour.—In the manufacture of glue and gelatine, and as a source of ammonia, bones have been long used. The residue was found to be an excellent manure in a much more soluble form than could be attained by any process of grinding. Steamed bones were thus brought under the notice of farmers. But before this, bones were boiled to extract the fatty matter and part of their gelatine, by soap-boilers for the manufacture of soap. The residue was found to be more active than ordinary crushed bones. We are now aware that in the manufacture of dissolved bones this fatty matter carbonises and forms an impervious layer over each fragment of bone, preventing the acid from acting upon it.

Fat in Manure disadvantageous.—The same process occurs in the soil. An impervious envelope is formed around the bone-fragments by the fat, and the

action of acids which are generated is prevented, thereby retarding solution. We would therefore infer that bone-meals of all descriptions would be enhanced as fertilisers if these fats were removed before grinding.

Steamed bone-flour undergoes a more searching process, as the bones are introduced into a Papin's digester, and submitted to the action of steam at a high pressure, which removes a portion of, and in some instances nearly all, the organic matter, thereby disintegrating the substance of the bone, which is afterwards reduced to an impalpable powder. The abstracting of the gelatine decreases the manurial value, as it is the only source of nitrogen; but the percentage of phosphates is largely increased, which counterbalances this fact to a certain extent. Fat is of no manurial value.

Burned Bones. — The burning of bones is a wasteful process to effect the same object. In this form they are largely imported from South America for the manufacture of superphosphates. In this process the nitrogen is entirely dissipated. No doubt it is a concentrated form in which to obtain phosphates, but the plan is not commendable. Its only redeeming point is that the charcoal resulting from the burning of bones can be used for other purposes, sugar-refining, &c., before it comes to the farmer as a manurial substance.

Analyses of Bone-manure. — The following are analyses of average samples:—

	Crushed Bones.	Bone-meal.	Steamed Bones.	Russian Bones (steamed).
Moisture	7.13	7.45	5.20	6.80
Organic matter[1] . .	36.61	41.85	17.50	16.70
Phosphate of lime . .	48.32	46.36	67.53	59.31
Carbonate of lime . .	7.11	3.66	9.31	...
Insoluble matter .	.83	.68	.46	...
	100.00	100.00	100.00	...
[1] Yielding ammonia .	4.56	5.27	1.94	1.80

Analyses similar to the above are very general in trade circulars. It may be explained, however, that bone-meal, made by crushing pure bones from cattle, horses, or sheep, would not contain quite so much as 5.27 per cent of ammonia. In a bone-meal with the above analyses there would likely be a good deal of skinny matter crushed up, or it might be made partly of the bone of fish. The Russian bones of commerce are steamed.

Dissolved Bones.—About the year 1840 a new departure was made in the manufacture of bones as manure. The development of this trade was rapid and extensive, but farmers became at last alive to the fact that the division of bones could not be carried to such a point as to suit the requirements of the turnip crop. Mechanical means had been tried, and had not, to the full extent, fulfilled the purpose.

But when Liebig announced that "the most easy and practical method of effecting their division is to pour over the bones, in a fine powder, half their weight of sulphuric acid diluted with three or four parts of water, and after they have been digested for some time, to add about 100 parts of water, and to sprinkle this acid-mixture (phosphate of lime) before the plough," it was thought a solution to the problem had been found.

The plan could hardly be said to have come into use, as it was open to much objection on account of the form in which the bones were to be applied to the soil. A dressing of 1 cwt. of the dissolved mixture, entailing the application of nearly a ton of water, was simply impracticable in most cases of ordinary farming. A remedy was found in putting less acid in the mixture, and thereby producing a nearly dry product which could be sown by hand or machine. This substance came quickly into favour with all classes of farmers, as they found the manure to be easy of application, rapid in its action, and in most climates and soils never failed to produce an increase of crops.

Dissolving of doubtful Advantage.

—From the accounts to which we have had access, there would seem to have been, until recently, a good deal too much manuring with dissolved bones. There can be no doubt of their efficacy, but we cannot help agreeing with Dr Aitken when he says, "Considering the enormous quantity of mineral superphosphates now available, I am strongly of opinion that it is a mistake to dissolve bones, and that they are put to a much better use by applying them in their natural state in as finely ground a condition as they can possibly be got. The germ-life in the soil and in the bones will very rapidly convert the whole into a form available for the nourishment of plants; but to dissolve bones in sulphuric acid is to kill out the germ-life within it, and retard the decay of any nucleus of bone it may contain."

Bones and Mineral Phosphates.—Bones contain nitrogen and phosphates. Mineral phosphate contains only phosphates, but when dissolved this phosphate is probably as efficient a plant-food as phosphate obtained from bones. Some chemists still maintain that the origin influences the manurial value of the phosphates; but the idea is gaining ground that the only difference which exists between the forms—bone and mineral phosphates—is the presence of nitrogen in the bones. This nitrogen, however, can be readily introduced in some other form; and thus would result a manure about equal to bones. To put it another way, ordinary dissolved bones are made up as follows:—

7 cwt.	bone-meal
14 "	coprolites
15 "	acid sulphuric
3 "	water
1 "	gypsum
40	

This will give about 22 to 25 per cent soluble phosphate, from 8 to 12 insoluble, and about 1 per cent ammonia. It is specially important to notice that the material from which the manure derives its name is present only to the extent of nearly 1-6th part, the balance being made up of cheaper materials. Now let a mixture of bone-meal and ordinary superphosphates be made up to give the foregoing percentages, and our point is made.

But there is another view. The farmer is paying the dissolved-bone price for materials which he can buy at a superphosphate rate. That is, for 2 tons of a substance which is made up to the extent of 33 cwt. of superphosphate materials, he is paying a dissolved-bone price.

Further elucidation of this, and the chemical changes which are involved in dissolving bones, are given under *Superphosphates*, p. 116.

The dissolving of bones and other manures has developed now into a great industry, and, as a consequence, all qualities are offered in the market, from high-class dissolved bone down to adulterated rubbish entirely unworthy of the name of manure.

Analyses of Dissolved Bones.—The following are average analyses of three classes of dissolved bones:—

	No. 1. Dissolved Bones.	No. 2. Dissolved Bones.	No. 3. Dissolved Bones.
Phosphoric acid in a soluble state [1]	10.68	9.92	9.40
Phosphoric acid in an insoluble state [2]	7.12	5.32	3.28
Lime, sulphuric acid, &c.	78.36	78.30	80.92
Insoluble matter	3.84	6.46	6.40
[1] Equal to tricalcic phosphate, rendered "soluble"	23.32	21.68	20.56
[2] Equal to insoluble phosphate of lime	15.56	7.76	7.20
Ammonia	3.03	2.00	1.38

Coprolites.

Origin of the Manure-trade.—It has been shown that a new era began in the agriculture of this country with the introduction of bones as a manure. As the results obtained became known and appreciated, increased attention was given to the question of manuring, and active research was made for other fertilisers.

Fresh substances were found, and proved to be successful and economical as fertilisers. A large increase in the demand for these manures rapidly arose,

and with this movement began the manure-trade of this country, which has developed from small beginnings to the immense volume of about 600,000 tons per annum.

Cambridge Road-scrapings. — In the rise and progress of this trade the effect of any substance when used as a manure was closely observed, and thus we can therefore understand how the road-scrapings of Cambridge came into notice. These scrapings, on being examined, were found to be in part composed of phosphate of lime, obtained from phosphatic nodules, which were dug up out of the underlying "greensand," and used for repairing roads. Dr Buckland, their discoverer, found these nodules to be a mineral phosphate, and consequently nearly insoluble. They are now known under the name of *coprolites*.

A considerable period elapsed after the discovery of these nodules before they came to be used as manure. The writings of Henslow and Hérapath, who minutely described the extent and composition of this manurial wealth, effected this object by bringing these resources under the notice of the Royal Agricultural Society of England.

Origin of Coprolite.—Coprolites, or dungstones, are the excrements and remains of saurians or lizards, *Ammonites*, *Belemnites*, &c.

Sources of Coprolite.—The digging of coprolites was at first confined to the midland counties, where they were found in the greensands of Cambridge, the green marls, the gault, the bone-beds of the Lias, Ludlow bone-beds, Suffolk Crag, &c. After a time immense deposits were found in various parts of Europe and America. These deposits are of various qualities. Those found in the Suffolk Crag, in Buckingham, &c., were at one time known as false or *pseudo-coprolites*, from their containing a considerable quantity of alumina and oxide of iron. It has been suggested by Dr Buckland that the coprolite of this description was at one time chalk, which, after absorbing phosphoric acid from the decay of organic matter, was ultimately altered by natural forces into a mineral phosphate.

Another theory as to the origin of these and other mineral phosphates has also had support. It was supposed that they were at one time nearly the same as many of the phosphatic guano deposits, and had been altered by rains and afterwards by changes in the earth's crust, so as to be converted into the nodules or phosphatic rocks, now so largely employed in the manufacture of *superphosphates*.

Dissolving or Grinding.—Until recently, chemists were of opinion that mineral phosphates, unless treated with acids, were practically useless as a manure. Modern research, however, has shown that, if ground to an impalpable powder, they are of considerable value as fertilisers.

We shall not here attempt to determine or pronounce upon their precise relative value in a dissolved or undissolved state. As yet, indeed, this question occupies a debatable position in chemical investigation. All, however, agree that coprolites, when dissolved, become a safe and valuable source of phosphoric acid for plant-growth.

Composition of Coprolites. — The following are average analyses of coprolites by Sibson :—

	Cambridge.	Bedford.	Suffolk.	Carolina.	French.
Moisture . .	1.24	2.06	1.03	1.04	1.90
Phosphoric acid .	26.80	23.52	25.50	25.70	20.80
Lime . . .	43.26	33.46	37.24	37.38	31.94
Carbonic acid . .	7.10	...	3.60	...	3.80
Other matters .	12.70	16.54	20.50	16.76	15.03
Sand . . .	8.90	24.42	12.13	19.12	26.53
	100.00	100.00	100.00	100.00	100.00
[1] Equal to tribasic phosphate of lime	58.50	51.34	55.67	56.10	45.41

The preceding are very similar in composition, and may be taken as fair representatives of the phosphatic nodules.

But there are many other sources of insoluble phosphates. We shall mention briefly a few of those best known.

Apatite, Phosphorite, and Phosphatic Layers.

These substances occur in varied proportions in nearly all rocks, but are more abundantly present in the Metamorphic. They are much alike in character and composition. The existence of these layers, veins, and pockets seems to be due to the decay of organic matter; the residue being mixed up with shells of various kinds in which phosphate of lime is present in considerable abundance—these being deposited during long periods of time, and compressed amongst the other rock-material. Granite and syenite seem to be more largely interspersed with these substances than other rocks, and we have, in consequence, the best corn-growing lands on soils which overlie these rocks.

Apatite is found largely in Canada and Norway, where it is present in veins and masses. It exists in lesser quantities in other parts of the world.

Phosphatic layers are generally poor in quality, and are met with in the Silurian rocks, notably in Wales. *Phosphorite* is very abundant in some parts of Portugal, but these sources have not as yet been fully developed in consequence of bad roads. It is more sparsely present in Spain and Germany. The Canadian phosphorite beds have not been fully explored. The specimens which have been sent to the market are extremely hard and brittle, very difficult to grind; the powder obtained being minute glassy particles of a crystalline form. This renders it more insoluble than most other phosphatic materials.

These substances are for the most part manufactured into superphosphates.

Composition of Phosphorite.—Undernoted are analyses of average specimens:—

	Canadian Phosphorite.	German.	Spanish.
Moisture	Traces.	1.30	Traces.
Phosphoric acid[1] . . .	35.30	28.02	33.60
Lime	47.22	37.11	42.02
Other constituents . .	11.98	15.44	8.11
Sand, &c.	5.50	18.13	16.27
	100.00	100.00	100.00
[1] Equal to phosphate of lime .	77.06	61.17	73.35

Sombrero or Rock Guano.

This substance is found in the West Indian island of Sombrero, hence its name. There can be little doubt that the greater part of the islands in the Caribbean Sea were at one time covered with guano deposits in the same manner as those found on the islands of the South American and African coasts. These deposits, by natural agencies, have been converted into the phosphatic rock which covers the greater part of this and the other islands of the West Indies. This rock has become known in the manure-trade as Sombrero guano, and is largely used in the manufacture of compounds and other soluble phosphatic manures.

"Redonda" and "Alta Vela" Phosphates.

The preceding are all phosphates in which the phosphoric acid is in combination with lime as a base. In Redonda phosphate we have instead of lime a base composed of alumina and iron. This substance can be applied to the soil in its natural state only in a finely divided condition, as the absence of lime in its composition prevents the treatment of it with acid.

There would seem to be a considerable amount of conflicting opinion as to the efficacy of this substance as a manure. Many hold it to be utterly useless. From its composition we would infer that it should become more readily available than many other mineral phosphates, for it not only depends on the fineness of division, but also on the composition whether a substance becomes more or less dissolved in the soil.

The hard, brittle, and crystalline character of some of the phosphorites, with little or no carbonate of lime or iron in their composition, must necessarily be

less soluble than those phosphatic materials in which these substances are present to the extent of about 11 per cent carbonate of lime, and 7 per cent oxide of iron. These substances being dissolved out of the minute particles, must render them more liable to disintegration.

Composition of Sombrero, Redonda, and Alta Vela.—The following is average analyses of a few of these materials by Sibson :—

	Sombrero.	Redonda.	Alta Vela.
Moisture . . .	6.50	21.13	16.50
Phosphoric acid[1] .	31.60	30.24	27.20
Lime	44.67	3.16	8.93
Other constituents . .	15.99	24.84	26.23
Sand	1.24	20.63	21.14
	100.00	100.00	100.00
[1] Equal to phosphate of lime .	68.98	66.01	59.38
Alta Vela contains . .	7.20 oxide of iron and 14.16 alumina.		
Redonda " .	3.64 "	15.72 "	

Thomas Slag.

We have in this substance not only the most recently discovered, but also the cheapest and most abundant source of phosphoric acid. It has been in the market only since 1886. The results obtained from carefully conducted experiments in Germany and this country clearly indicate that this substance is an excellent source of phosphorus to plants. It is, indeed, more quickly available to plants than any previously known form of insoluble phosphate. As it is now produced in Europe to the extent of about 600,000 tons per annum, the discovery of its manurial value is of great importance to agriculture.

Source of Thomas Slag.—Thomas slag is a by-product obtained in the conversion of pig-iron into steel. Before the discovery of this new process, all the slag resulting from the Bessemer method was treated as a waste product, and it often became a serious difficulty with manufacturers how to get rid of this supposed rubbish. It was therefore allowed to accumulate in those unsightly heaps which are always seen in connection with iron factories.

Manufacture of Thomas Slag.—The new process was patented in 1879 by the inventors, Messrs Thomas & Gilchrist, but the waste product was not utilised until some six or seven years later. The method consists of mixing the molten iron with about 20 per cent of lime. The converter, which is a large pear-shaped vessel, is also lined with lime instead of brick. The various impurities, such as manganese, silicon, phosphorus, and carbon, combine with the oxygen present in a stream of air which is forced through the molten mass, and either burns off or forms oxides with these substances. But on an increase of the already high temperature the phosphorus is converted into phosphoric acid, which combines with the lime, and the resultant product is the Thomas slag, or phosphate of lime.

Solubility of Slag.—This substance can be readily ground into a very fine powder; and after being passed over powerful magnets, which abstract a part of the iron, it is presented to the farmer in the best form for application. In this state it is quickly rendered available to the plant by the carbonic acid and water present in every arable soil. This solubility arises from its peculiar composition.

In bones and mineral phosphates we have three atoms of lime as a base combining with one atom of phosphoric acid to form the salt termed phosphate of lime. The combination may be stated thus, it being remembered that the atomic weight of calcium is 40, oxygen 16, and phosphorus 31 :—

		Chemical formula.		Weight.
Lime Lime Lime	Phosphoric acid	CaO CaO CaO	P_2O_5 =	56 56 56 = 142

Now, Thomas slag has four molecules of lime in its composition, in combination with one molecule of phosphoric acid, thus—

		Formula.		Weight.	
Lime	Phosphoric acid	CaO	P_2O_5 =	56	142
Lime		CaO		56	
Lime		CaO		56	
Lime		CaO		56	

In other words, 168 parts of lime are combined with 142 parts of phosphoric acid in the one instance, and 224 parts of lime with 142 parts of phosphoric acid in the other. That is to say, in Thomas slag the acid is combined with too great a proportion of lime to enable it to cohere firmly. To put it in still another way, its chemical affinity is weakened from being over-saturated with lime, so that the compound is more readily broken up. Hence the solubility of Thomas slag.

Oxide of Iron in Slag.—There seems to be one drawback which, in the opinion of many farmers, detracts from the value of slag as a manure. This is the great quantity of oxide of iron in its composition, many samples containing from 10 to 20 per cent and over. From experiments conducted by Sir John B. Lawes, and in Germany, it seems that the presence of this material has little or no effect on the growth of crops. The farmer, therefore, just loses the value of the fertilising ingredients in proportion to the quantity of this substance which may be present in the slag bought by him.

Composition of Slag.—Slag also contains, beside phosphate and silicate of lime, a considerable quantity of caustic or free lime and magnesia. The following is an average analysis of Thomas slag:—

Phosphoric acid . .	18 per cent
Lime	50 „
Oxides of iron, &c. .	22 „
Silica	7 „
Magnesia . .	3 „

The quantity of phosphoric acid in a sample depends on the amount of phosphorus present in the iron, and the quantity of lime which is added to the molten liquid. If an excessive quantity of lime be added, then the residue must be poor in phosphoric acid, and *vice versâ*. The caustic lime, although a good manure, prevents slag forming an all round ingredient in mixing manure, as in this form it is a strong alkaline base, which will readily drive out a volatile one, as ammonia. If these be mixed, the lime combines with the sulphuric acid, and the ammonia escapes in a volatile state into the atmosphere.

Further information on this point will be found under mixtures and mixing.

Soluble Phosphates or Superphosphates.

When Sir John Bennet Lawes, about the year 1840, announced that he could obtain *soluble phosphate of lime* from the mineral phosphatic nodules as represented by *coprolites*, it is not to be supposed that he then realised that from this discovery a special industry would develop, which would go on increasing in volume until it reached, as it had done by 1888, the placing upon the markets of Great Britain of over half a million tons of superphosphates yearly. The great value of this discovery to the agricultural world becomes apparent by a consideration of the large and increasing quantities of superphosphate which farmers require under the changes which the application of artificial manures has effected in the rotation of crops, and the ever-diminishing supply of phosphates.

Composition of Phosphate of Lime.—Phosphoric acid and lime in combination are the principal ingredients in the salt, phosphate of lime. These substances are present always in the same proportion whether the phosphate is derived from bones or mineral phosphatic materials—with the one exception of slag. This combination is known as insoluble, tribasic, or tricalcic phosphate, which consists of three atoms of lime and one atom of phosphoric acid, thus—

		Formula.		Weight.	
Lime	Phosphoric acid	CaO	P_2O_5 =	56	142
Lime		CaO		56	
Lime		CaO		56	

Solubility of Phosphate of Lime.—In this form phosphate of lime is very slowly soluble. Were it not that this substance when applied to the soil comes into contact with water impregnated with carbonic and other acids, the phosphate would remain unaltered for years. But the carbonic acid and water possess considerable dissolving power, and when insoluble phosphate is acted upon by carbonic acid, a molecule of lime is taken away, and water takes its place, so that

the phosphate is now changed into a more soluble form, known as biphosphate of lime or dicalcic phosphate.

Precipitated, Reverted, or Reduced Phosphates.—This form is also effected by mixing dissolved phosphates with bones, slag, or caustic lime, before applying it to the soil. These phosphates also assume this form after being applied, as the phosphoric acid rendered soluble will then combine with any free base which may be present in a fertile soil. The combination may be stated thus—

		Formula.		Weight.	
Lime Lime Water	Phosphoric acid	CaO CaO H_2O	P_2O_5 =	56 56 18	142

The preceding form may be looked upon as the natural process by which phosphate of lime is rendered soluble, and consequently available for plant-food.

Dissolving of Phosphate of Lime.—We have next to consider the artificial method of rendering insoluble phosphates soluble. The raw material is first ground into a fine powder, after which it is placed in a vessel termed a mixer, and treated with sulphuric acid. It depends upon the composition of the raw material and the strength of the acid as to the exact proportions in which these substances are mixed, more acid or less being employed in proportion to the carbonate of lime present. The general rule is to give as much acid as the material will take up quickly and dry readily after. In practice the quantity of acid varies from one-third to the full weight of the phosphatic material.

The value of a superphosphate depends on the amount of soluble phosphates present. It is therefore questionable policy to stint acid — at least from a manufacturer's point of view — as the unit value of soluble is much greater than that of insoluble phosphates. For this reason, in low-class superphosphates the material is saturated with acid to prevent reversion, with old mortar, chalk, and other inferior substances which sometimes form a considerable portion of such mixtures. When the acid is put into the mixer, chemical action at once begins by the sulphuric acid, which is strong, driving out the weaker carbonic acid. It then attacks the phosphoric acid combination, and abstracts two atoms of lime from it, the vacancy being made up with water. After a short time the bottom of the mixer is opened, and the whole mass drops into an enclosure known as the den. In a day or two the mixture dries quickly, it is then passed through a disintegrator, bagged up, and sold under the name of "superphosphate."

This product, on examination, is found to have undergone a change different from the other forms, as the compound now retains only one atom of lime in combination with the phosphoric acid, and may be stated thus—

		Formula.		Weight.	
Lime Water Water	Phosphoric acid	CaO H_2O H_2O	P_2O_5	56 18 18	142

In chemical parlance this substance is designated monocalcic phosphate, but it is usual in analysis not to state the quantity of this substance, but the quantity of tricalcic phosphate from which it was made—that is, the tribasic or tricalcic phosphate of lime rendered soluble by an acid. In this form it is in its most soluble condition, as it can be held in solution by water.

Biphosphate. — But some chemists consider that in this state the phosphoric acid is not available for plant-food—that before becoming so, it has to pass into the biphosphate form. When this change is effected, it becomes a precipitate, and is then in the most finely divided condition a substance can assume. Many farmers consider the biphosphate the best form in which to apply phosphate of lime, holding that it is more quickly effective upon crops, and that the superphosphate form is over-soluble, and liable to escape into the subsoil or drains if a base is not present.

But there are advantages which arise from the use of phosphates, as in superphosphate—viz., the greater power of diffusion a substance has when it is held in solution by water; because, wherever this water, which is impregnated with phosphoric acid, comes into contact with the soil in which lime or other base is present, there a portion of the phosphoric acid is precipitated, and in this manner the phosphoric acid is interspersed

throughout the soil in a way which could never be attained by any mechanical means.

Bone or Mineral Phosphate.—It is held by eminent chemists that the soluble phosphates obtained from mineral phosphates are equally as good as those from bones, and that there is no special virtue in one form over the other. It is therefore of little importance to the farmer from which source his soluble phosphates are made, provided the material is fully dissolved, and in a dry, powdery condition.

But from this we do not infer that superphosphates are as good a manure as dissolved bones. We merely conclude that the soluble phosphates present in each are equal in value as fertilisers. The dissolved bone owes its greater efficacy to the nitrogen; but then this nitrogen can be supplied to the superphosphate either as bone-meal or sulphate of ammonia, by which means we can secure a cheaper manure, with an equal if not a greater amount of fertilising matter.

An additional benefit which bone possesses over mineral phosphate is due to its containing a certain percentage of organic matter, which, in the process of decay, gives rise to carbonic acid and other organic acids, which have a dissolving action on the phosphate of lime,—an advantage of considerable importance, especially when no dung is being applied.

Composition of Superphosphates.—Superphosphates are of three kinds—low, medium, and high-class. As a rule, amongst the superphosphates which abound in the market the medium is the best form, as the first too often contains a considerable quantity of coarsely ground phosphate, which, in that rough condition, is comparatively worthless as a manure; whilst high-class is not unfrequently in bad condition, being wet and lumpy, and difficult to handle. But it should be understood that these defects in the so-called low-class and high-class superphosphates are not always present. Better attention is now given than formerly to fineness of grinding, and with skilful dissolving the high-class superphosphates should be dry, powdery, and quite free from lumps.

The percentage of soluble phosphates which average samples should contain is shown below:—

	High-class Superphosphate.	Medium Superphosphate.	Low-class Superphosphate.
Soluble phosphate (per cent) . .	35	28 to 30	23 to 26

Characteristics of Phosphatic Manures.

In the selection of the form in which to apply phosphate to his crop, the farmer has to consider the character of the soil, climate, and crops to be grown. The remarks made upon nitrogenous manures apply with equal force to all kinds of phosphates.

Activity of Phosphatic Manures.—We have already tried to impress on the minds of our readers that the solubility of a manure depends on the minuteness of its division: we can have therefore little difficulty in placing them in the order of their activity, beginning with those which come into action slowly—crushed bones, finely powdered mineral phosphate, fine bone-meal, steamed bones, precipitated phosphates, Thomas slag, dissolved phosphates.

Bones are the slowest in their action, and become available as plant-food only after being mixed with the soil for some time. It is therefore a safe rule to apply them early. In some soils they come more quickly into action than in others. This is especially the case in porous soils where organic matter is present. In clays, and soils of like texture, they may remain unchanged for years. Bones are, however, good "stayers"—that is, being slowly soluble, they last long, and raise the fertility of the soil. Therefore all mixtures of manure intended to last a rotation should contain a proportion of bones. In a wet climate bones are also rendered more quickly soluble than in drier parts. Indeed, in wet seasons bones decompose rapidly.

The softer or less compact forms of *mineral phosphates* when ground into a very fine powder, have been found to be moderately quick-acting manures, about equal, some consider, to very finely ground bone-meal or bone-ash.

Finely ground *steamed bone-flour* is the most active form of bones prepared by mechanical means, and gives a high-class

superphosphate when treated with an acid. The fineness of division of this substance counterbalances the want of organic matter with relation to solubility. But this preparation is coarse when compared to *precipitated or reverted phosphates*, which possess the highest degree of solubility of any of the forms of phosphates except *slag*. Slag comes next to superphosphate, and has a great future before it, being, as we have seen, the cheapest source of phosphoric acid in the market at present, while the supply is abundant.

Dissolved manures are the most active. The chief advantage of this solubility is their certainty of action, the rapid manner in which they become available in any soil or climate. The young plant is in consequence supplied with this essential ingredient at a period of growth when it is liable to sustain damage from untoward influences which may infest its surroundings. An abundant supply of manure or food at this critical period to a great extent determines the future crop, an increased yield of well-filled grain and early maturity being the results.

Large crops require large doses of manure, and short-lived crops require quick-acting manures. A crop such as wheat, which occupies the ground for a long period, will not be benefited to the same degree by a ready supply of phosphates as a short-lived crop like barley. Wheat abstracts the ingredients at leisure, and can search for them over a much larger area of the soil. And as phosphates are present in some proportion in all soils, this crop can, as a rule, acquire all its wants during the period of growth. Barley, on the other hand, grows rapidly, building up its tissue in a comparatively short time, and, owing to its root-surface, has not the area nor the time to search for its supply of phosphates.

In the well-known work, 'How Crops Grow,' we are told that the phosphorised oils require phosphates for their elaboration; that phosphates increase the diffusive rate of albumen, and thus help its transference to the different parts of the plant; and that phosphates co-operate with the other ash ingredients in building up the proximate constituents, such as starch, dextrine, &c., and is ultimately deposited in the seed. We are also aware that a deficient supply of phosphates produces light grain and diminished yield. Phosphates produce dense roots, of excellent feeding quality and high keeping properties.

POTASSIC MANURES.

The use of potash manures is of recent date. Even yet many farmers do not consider the application of potash to the soil necessary.

Sources of Potash.—The only available sources of potash, before 1860, were wood-ashes, sea-weed, and farmyard manure. In 1859, vast deposits of potash salts were found by the Prussian Government when sinking a shaft at Stassfurt in the hope of discovering rock-salt. Overlying large deposits of rock-salt, they found layers of kainit, a name given to carnallite or muriate of potash; and magnesia, polykalite or sulphate of potash; gypsum and kieserite, or sulphate of magnesia. Similar deposits were also found at Leopoldshall, in Anhalt.

The discovery of these deposits put the use of potash as a manure within the reach of the farmer. It can now be bought at about 35s. per ton, containing on an average 23 per cent of potash.

Use of Potash.—But notwithstanding its low price, potash has not come into general use. As a rule, it can be applied with advantage only to certain crops, and on land deficient in clay, such as sandy or peaty soils.

When farmyard manure is applied, a separate dose of potash is unnecessary. Indeed it would be liable to lessen the produce, and also lower its quality, as with the potash in the dung there would be more available potash in the soil than would be beneficial for the crop. On most soils containing a fair proportion of clay, and where a good deal of farmyard manure is used, there is, as a rule, a sufficiency of potash. But where it is deficient, the gain in produce obtained by a small application of potash, at a cost of a few shillings per acre, is often remarkable. By observation and experiment with light doses on plots, farmers may ascertain if their soil needs potash, and if so, its application in moderate quantity

will be sure to be profitable. Potash has been found of some benefit when applied to mangels, and appears to be of considerable benefit when mixed with other manures and applied as a top-dressing for hay and grass seeds. It also may be applied with advantage to leguminous crops, beans in particular.

Wherever applied it ought to be sown early, and care should be taken not to apply it in conjunction with farmyard manure. It is positively injurious to green crops when given in excess.

GYPSUM.

Sources of Gypsum.—Gypsum, or sulphate of lime, occurs as rocks in the form of beds, generally in conjunction with rock-salt. In the compact form it is commonly known as alabaster and selenite. Many of the deposits owe their origin to the evaporation of salt water, which contains gypsum in solution. At one period, where rock-salt is now found, there must have been inland lakes or seas, and by changes of the earth's surface the outlets have been gradually cut off from the sea; so that all the saline matter brought down by the drainage has been accumulating, the water becoming more and more impregnated with these salts, and thus, when evaporation has gone on for a certain period, the salts cannot be longer held in solution, and, becoming crystallised, they are deposited in the form of beds, which by compression assume the compact form.

Use of Gypsum.—From an agricultural point of view, gypsum is valuable chiefly as an absorber of ammonia (see p. 527, vol. i.) It is of benefit to clover and other leguminous crops.

The value of gypsum as a manure was the subject of much discussion about 1850 to 1860; but since the introduction of dissolved phosphates it has been unnecessary for the farmer to trouble himself about it, as the application of 5 tons of superphosphate involves an application of 2 tons of gypsum.

GAS-LIME.

In the manufacture of gas, many impurities have to be got rid of before the gas is ready for combustion. Amongst these are gas-liquor, from which sulphate of ammonia is obtained, and gas-lime, which is produced by spreading quick or caustic lime over plates in a close chamber, through which the gas containing sulphuretted hydrogen is forced. This latter substance combines with the lime, forming in the purifying chamber sulphide of lime. In this form it is destructive to vegetable life; but after exposure to the atmosphere it absorbs oxygen, and is thereby changed into *sulphate of lime or gypsum.* The caustic lime which may be present is also changed into carbonate.

Use of Gas-lime.—Gas-lime ought to be applied in autumn, or allowed to lie some months before using, so as to allow time for the changes just explained to take place. It is unsafe to apply it to any growing crop.

Many Berwickshire and Roxburgh farmers mix gas-lime and salt, and apply the mixture to their leas which are to be broken up for oats. They consider this application to be of service to the corn crops, and a preventive of anbury or finger-and-toe in the green crop. Gas-lime is also much used as an insecticide.

COMPOUND MANURES.

In addition to the various manures already enumerated, there are in the market many *compound manures* or special crop mixtures bearing different names, such as cereal, turnip, potato, bean, and grass manures.

Disadvantage of Compound Manures.—Many of these mixtures are skilfully made up, and, when manufactured by respectable firms, analyse well, and give good results on soils for which they are adapted. But there is one great drawback to this system of preparing manures, and it is this, that with such variation in soil, climate, and customs of farming, it is impossible to compound one manure equally suitable for all farms, even in one district. Moreover, the trade in compound manures opens a wide field for the unscrupulous dealer who would sell inferior stuff as good material. Upon the whole, therefore, it is safer for the intelligent farmer to avoid mixed manures and select fertilisers from sources as to which there can be no

suspicion, and blend these in mixtures suitable for the soil and climate where they are to be applied.

Still there are many farmers who are not sufficiently acquainted with the characteristics of the various manures to enable them to ensure perfect mixing, and in these cases it will be advantageous to have the mixtures prepared by a thoroughly respectable firm, by whom the composition of the mixture will be guaranteed.

ECONOMICAL PURCHASING OF MANURES.

In the purchasing of manures there are a few points which farmers should always keep in view. From simple examination of any article sold as manure, the purchaser can have little or no idea of its quality or value as a fertiliser. For this reason the farmer ought—

(1.) To buy only from respectable firms.
(2.) Never buy without obtaining a guaranteed analysis.
(3.) Always buy the valuable ingredients from the cheapest sources in the market.

The first point is so self-evident as to require no further remarks.

Analysis explained.

It may be useful to explain some of the terms used by chemists in an analysis of manure.

Insoluble and Soluble Phosphates.—As to the meaning of the terms insoluble phosphate and soluble phosphate some explanation has already been given in the notes upon superphosphate, p. 117. It was there seen that *soluble phosphates* always mean *tribasic phosphate of lime made soluble by an acid.* It is no matter whether they are termed monobasic phosphate, monocalcic phosphate, biphosphate, phosphoric acid in a soluble state, or superphosphate, the term superphosphate is generally applied to all dissolved phosphates in which ammonia is not present.

In analyses of manures, the term phosphoric acid in a soluble state is often met with. This means the acid will melt or dissolve in water, like sugar or salt; but to assist practical men to arrive at conclusions more correctly as to the value of the manures, the percentage of dissolved phosphate of lime is also given—that is, the amount of tribasic phosphate of lime or bone-earth required to give that quantity of phosphoric acid in a soluble state.

Organic Matter.—Chemists apply this term to every substance that will rot or decompose by "heating" or burn by fire—no matter whether it belong to the animal or vegetable kingdom. The value of the organic matter in a manure depends mainly upon the amount of nitrogen in its composition, and whether or not that nitrogen becomes readily available for the use of plants. For instance, straw, wool, blood, or sawdust are all organic matters, but the amount of nitrogen present in each is very different. Straw and sawdust in themselves may almost be looked upon as non-nitrogenous substances, while blood and wool show a very large percentage of nitrogen.

Again, we have to consider how soon the nitrogen shall become available for food to plants. This must necessarily depend upon whether those substances are subject to rapid decomposition or otherwise. Blood decomposes quickly, while wool may lie in the soil for years unchanged, and its effects upon vegetation cannot therefore be the same, because all substances before they become available as a manure must be broken up into the elements of which they are made up, or in other words, *decompose or rot.*

It should also be noted here, as already indicated, that organic matter is of value as an indirect improver of the texture and mechanical properties of a soil as well as the generator of carbonic and other acids, whose action on the dormant fertilising constituents of a soil is most beneficial.

Nitrogen and Ammonia.—It may be here explained that when nitrogen is liberated from a substance, it may go into combination with hydrogen and form ammonia, or it may be evolved as free nitrogen and pass off in the atmosphere, or it may be converted into nitric acid, which, combining with lime, potash, or soda, forms nitrates of these bases. But in most cases where organic nitrogen

occurs in a manure it becomes converted into ammonia—hence the term, nitrogen equal to ammonia.

Alkaline Salts.—These may be accidentally present or may be added in the drying agents employed. They consist chiefly of sulphate of soda or potash salts. The latter is of considerable value, but the former is not of much importance.

The foregoing are the more valuable constituents in the analysis.

Lime and Sulphuric Acid.—Lime and suphuric acid are present in pretty large quantities in the form of sulphate of lime or gypsum, this being a result of the sulphuric acid applied to render soluble the insoluble phosphates. The acid, as before explained, acting on the phosphate of lime, abstracts from the phosphoric acid two equivalents of lime; while, where carbonate of lime is present, it drives off the carbonic acid and combines with the lime to form the foregoing salt. Gypsum is also employed as a drying agent.

Moisture.—Moisture is present in a manure as the water of combination, and also as the water which is mixed with the materials to enable the acids employed to act with the greatest advantage.

The amount of moisture present in a manure is of considerable importance to the purchaser, as when a quantity of manure dries, the water lost by evaporation is a direct loss of weight.

The Cheapest Source.

The greatest difficulty the farmer has to encounter when purchasing manure is to know the cheapest sources from which to obtain phosphoric acid, nitrogen, and potash. In order to enable him to form an approximate opinion of relative values, we shall try to explain the theory of valuation by units, preluding it with the remark that the *value of a manure to the farmer* depends on the amount of valuable ingredients which may be present in its composition, but that its *market price*, like that of all other commodities, is regulated by the law of supply and demand.

Valuable Ingredients of Manure.—The valuable constituents in manure are: (1) nitrogen, equal to ammonia, quickly available, as in nitrate of soda and sulphate of ammonia; (2) nitrogen slowly available, as in bones, blood, &c.; (3) phosphoric acid quickly available, as in superphosphate; (4) phosphoric acid slowly available, as in bones, guano, &c.; and (5) potash, as in kainit.

Nitrogen, phosphoric acid, and potash are available from many other sources, but the foregoing will give an average. What the farmer has to carefully consider is the form in which these are present, whether *quickly or slowly available*, and then judge which will be most suitable for his purpose.

Unit Value.—Let us now see how the unit value is arrived at. Taking the prices per ton stated below as the selling price of the manures, and dividing the cost price by the percentage of units of the various useful ingredients, we find the value per unit of these ingredients would be as follows:—

			Per ton.			Per unit.		
Sulphate ammonia	= 24 per cent	ammonia, at . .	£12	5	0	= £0	10	3
Nitrate of soda	= 19 "	" at . .	10	12	6	= 0	11	3
Phosphatic guano	= 46 "	phosphates, at .	2	12	6	= 0	1	2
Slag	= 40 "	" at .	1	10	0	= 0	0	9
Superphosphate	= 27 "	soluble phosphates, at	2	15	0	= 0	2	0
"	= 23.5 "	" at	2	7	6	= 0	2	4
Muriate of potash	= 50 "	potash, at . .	7	7	6	= 0	3	0
Sulphate of potash	= 26 "	" at . .	4	2	6	= 0	3	2
Bones	= 50 "	phosphates	5	15	0	= 0	1	4
	= 4.5 "	ammonia at .				= 0	10	3

The only difficulty is in regard to a compound manure such as bones. In such a case the unit value of the constituents of a similar substance is taken. Sulphate of ammonia is adopted in this instance. The bone-manure, we have seen, contains 4½ per cent of ammonia. This multiplied by 10s. 3d. (the cost of ammonia per unit in sulphate of ammonia), gives £2, 6s. 2d. as the proportion of the cost of the bones represented by the 4½ per cent of ammonia. This

deducted from the cost price of £5, 15s. per ton, leaves £3, 8s. 10d. for the 50 per cent of phosphates.

The foregoing, of course, cannot be taken as hard-and-fast rules. The chemist generally exercises a good deal of discretion, and often raises the unit value above what it will actually work out upon paper, much depending on the source of the material and its condition. For instance, the phosphates in bones, although showing a net unit value of 1s. 4d., may, on account of the first-class origin of the phosphate, be worth perhaps 3d. to 4d. per unit more. The foregoing figures will, however, give a useful idea of the approximate value, and indicate how, from the cost price and analysis, the value per unit is arrived at.

Estimating the Value of a Manure.—Now, let us reverse the process, and from these values per unit and the analysis of a manure, find what the cost price per ton should be. Take, say, *dissolved bones*, showing analysis of—

22 per cent soluble phosphate, worth 2s. 2d. per unit.
12 " insoluble " worth 1s. 2d. "
2¾ " ammonia, worth 10s. 3d. "
The total cost per ton should be £4, 9s. 10d.

Dissolved bones with this analysis can just now be bought at £4, 10s. per ton, and are therefore fair value in comparison with other fertilising substances.

Guide to Analysis.—The following table, compiled by Dr Aitken, will be found very useful in *reading* and understanding an analysis of manures:—

Amount of nitrogen,		multiplied by 1.214 gives amount of ammonia.		
"	"	" 6.3	"	albuminoids.
"	ammonia,	" 3.882	"	sulphate of ammonia.
"	"	" 3.147	"	muriate of "
"	"	" 3.706	"	nitric acid.
"	"	" 5.0	"	nitrate of soda.
"	potash,	" 1.85	"	sulphate of potash.
"	"	" 1.585	"	muriate of "
"	phosphoric acid,	" 2.183	"	phosphate of lime.
"	"	" 1.4	"	biphosphate.
"	"	" 1.648	"	soluble or mono-calcic phosphate.
"	soluble phosphate,	" 1.325	"	phosphate of lime.
"	biphosphate,	" 1.566	"	"
"	lime,	" 1.845	"	"
"	"	" 1.786	"	carbonate of lime.

MIXTURES AND MIXING.

Dangers of Careless Mixing.—In mixing manures, a knowledge of their character and composition is indispensable if loss is to be averted. Indiscriminate or careless mixing is almost certain to end in loss of fertilising material, and may even, by generation of poisonous gases in a close compartment, incur danger to human life.

It should therefore be kept in view that while the substances used as manure are more or less in the form of salts, which are harmless in themselves, yet if their complex forms are broken up, the products of the decomposition assume a very different character.

Chemical Processes in Mixing Manures.—The chemical processes which take place in this decomposition need not be fully described here. For all practical purposes, the substances which result may be regarded as acids in chemical combination with alkalies as bases. In chemical action, a strong or free acid will drive out a weak one, and a strong alkali will usurp the place of one possessing a less degree of affinity for acids. If we examine our manure-lists, we find that in

(1.) Highly soluble phosphates, to which, as is sometimes the case, an excess of acid has been applied, there is present free sulphuric acid; in

(2.) Nitrate of soda—an alkali having a strong affinity for sulphuric acid; in

(3.) Slag—a strong alkali in the form of caustic lime; and in

(4) Sulphate of ammonia—a weak or volatile alkali, ammonia.

When soluble phosphates are mixed with nitrate of soda, a portion of the phosphoric acid rendered soluble abstracts a portion of the soda from the nitrate of soda, the products of the decomposition being lime and soda and an orange-coloured gas, better known as nitric acid vapour—a deadly poison. If ⅓ of nitrate of soda and ⅔ of superphosphates are mixed, and allowed to lie for six weeks or so, it may be found that nearly ⅓ of the nitric acid has been lost from this cause alone.

Again, if superphosphate and bones or slag are mixed, and allowed to remain for some time, the soluble phosphoric acid will combine with another molecule of lime, and more or less precipitates, reverted or reduced phosphates, will be produced.

Then if we mix sulphate of ammonia with slag, the caustic lime of the slag will drive out the ammonia, which, being volatile, will become dissipated in the atmosphere, and the resulting product becomes sulphate of lime or gypsum.

Comparatively few realise the loss and disappointments which have occurred to the great body of farmers by haphazard mixing of manure. The fact is, there are very few manurial substances which can be mixed at random, and allowed to lie, without some important change occurring in their composition.

Safe Mixtures.—The following manures may be mixed with impunity: (1) bones with nitrate of soda or sulphate of ammonia; (2) superphosphate and sulphate of ammonia; (3) bones and slag; and (4) slag and nitrate of soda. These mixtures will not, however, suit the requirements of farm practice. Organic nitrogen, such as fish guano or Frey Bentos guano (or meat-meal), may be mixed with any other manure without incurring loss.

Method of Mixing.—The following plan of mixing has been adopted with a fair amount of success. As short a time as possible before application, the superphosphates are emptied, and the lumps are broken by striking the lump a smart blow with the back of the shovel. Next, a heap of bones, and another of slag, are put down, leaving a clear space in the centre. A man is now placed at each heap, and alternate shovelfuls, less or more—the quantity being determined by the relative proportion of materials desired—are thrown into the centre, where a new heap is formed containing the three materials. After this mixture is made, it is turned over, care being taken to always shovel the material from the bottom of the heap. The top portions of the material slip down, and thus by shovelling from the bottom, a thorough mixing is brought about.

In a day or two the sulphate of ammonia or nitrate of soda, when such is to be applied, may be added. The mixture is then driven to the field in carts, the mixing process being completed by the material being shovelled from the bottom of the heap into the cart. When the manure is to be sown by hand, equal quantities should be placed in each cart, in order to facilitate even application.

By mixing in this manner, the risk of loss through any excess of sulphuric acid having been added to the superphosphate will be averted, as any free acid will combine with the free lime of the slag, or with the bones if there is no slag in the mixture. A neutral salt is thereby formed and loss prevented. As already indicated, it would be unwise to allow a mixture of fine steamed bone-flour or slag and superphosphate to lie long, as the phosphates in the superphosphates would be precipitated by the carbonate of lime in the bone-flour, or by the caustic lime in the slag.

Another Method of Mixing.—Mr William Grant, Wester Alves, Morayshire, writing in the *Farming World* (p. 206, 1889) thus describes his method of mixing manures for turnips: "The mixing is done in a turnip-shed, about 16 ft. square, as follows: A layer of bone-manure is laid down over the whole area, next a layer of superphosphate, next another of bone meal or dust, on which is put a layer of fish guano; then another of the bone-meal, on which is laid a layer of kainit, and the same system gone over a second time till a quantity sufficient for 20 acres is laid down. A layer of the bone-manure is always put between each of the other kinds used, and, as a rule, only a day or two before being required for use. The heap has

sometimes lain two weeks without, as far as I could see, sustaining any injury; but I am always careful to have a layer of the bone-meal between the other layers, and *do not stir up the heap till we begin to use it.*"

Mixtures injured by lying long.—If a long time is allowed to elapse before application, then reversion of phosphates will set in; nitric acid and ammonia will be evolved, although in less degree; and the mixture will become damp and lumpy, and form into cake, which will prevent its even distribution.

Early application after mixing is therefore a matter of great importance.

Guano, dissolved bones, superphosphate, and sulphate of ammonia ought all to be riddled, and lumps broken before mixing.

Compounding Mixtures and Character of Manures.—In order to enable the farmer to make an approximate calculation of the quantities of the several manures, he will require to make up a mixture containing certain proportions of phosphoric acid, soluble; phosphates, insoluble; nitrogen, and potash, we append a very useful table compiled by Dr Aitken, slightly condensed:—

Nitrate of Soda.—The most available source of nitrogen; contains 95 per cent pure nitrate, equal to 19 per cent ammonia.

Sulphate of Ammonia.—Not so quickly available; contains 95 per ceut pure sulphate of ammonia, equal to 25 per cent ammonia.

5 parts nitrate equals 4 parts sulphate of ammonia.

5 parts nitrate equals 1 per cent of ammonia.

Dried Blood.—A slowly available source of nitrogen; contains 12 to 16 per cent ammonia.

Horn, Shoddy, Wool-waste.—Insoluble nitrogenous materials—therefore slowly available; containing about 17 per cent, 5 to 10 per cent of ammonia respectively.

Peruvian Guano.—A nitrogenous manure containing soluble and insoluble nitrogen—therefore in part available when applied, and balance slowly available; contains from 8 to 10 per cent ammonia, and from 30 to 40 per cent phosphate of lime, slowly available.

Low-class Guano.—Contains less ammonia and more phosphates, 3 to 5 per cent of ammonia, and 40 to 50 per cent phosphates.

Standard Guano.—Being similar to improved, equalised, fortified, &c., these are mixtures of low-class guano and sulphate of ammonia, and are generally guaranteed to contain 8 to 10 per cent ammonia.

Fish Guano.—Should contain from 10 to 12 per cent of ammonia, 18 to 30 per cent phosphates, and not more than 3 per cent oil. These substances are present in insoluble compounds, therefore this manure is slowly available. The oil retards decomposition.

Frey Bentos Guano.—Contains 6 to 12 per cent ammonia, and from 16 to 30 per cent phosphates, both in an insoluble form, consequently slow in their action as manures.

Bone-meal.—Contains on an average 50 per cent phosphates, and 4½ per cent of ammonia. These are insoluble and slow acting. Their solubility depends on the fineness of their division.

Steamed Bone Flour.—Contains on an average 60 per cent phosphates and 1½ per cent ammonia. This material can be ground into very fine powder, and is quicker in its action than bones, ground or fermented.

Pure Dissolved Bones.—These ought to contain about 20 per cent soluble and 10 per cent insoluble phosphates, with 2½ to 3½ per cent of ammonia. When pure, this substance is the most soluble and best form of phosphates. It is, perhaps, also the dearest.

Dissolved Bones.—Differ from the preceding by being largely composed of mineral phosphates and nitrogen obtained from cheap sources; dissolved together so as to generally contain 15 to 30 per cent soluble phosphates, and 1 to 3 per cent of ammonia—to be purchased with caution.

Superphosphates of a high class are made from mineral phosphates, which contain a high percentage of phosphate of lime. They contain between 30 and 40 per cent of soluble phosphates.

Medium-class Superphosphates contain from 26 to 28 per cent soluble phosphate.

Low-class Superphosphates are dear at comparatively low prices, and it is a safe rule to avoid them.

Mineral Phosphates, Coprolites, &c., ought to contain on an average between 50 and 60 per cent of phosphate of lime, and be ground into an impalpable powder.

Slag ought to contain from 36 to 41 per cent phosphate of lime, and the material, as also mineral phosphates, be so ground that 85 per cent of it will pass through a screen containing 10,000 holes to square inch.

Uncertain Character of Compound Manures.—Compound manures are so numerous and varied in their composition that it is impossible to indicate those most suitable for any crop or soil. They usually contain phosphate, nitrogen, and potash in various proportions. But the purchaser must not only ascertain the percentage of these ingredients which may be present, but also the sources from which they are derived, and the form in which these are present.

Home Mixing preferable.—It is therefore considered more prudent for

a farmer to buy a suitable combination of materials derived from known sources, such as bones, superphosphate, nitrate of soda, guano, &c., and make up the desired mixture for himself—that is, if he has taken the very necessary precaution of acquiring a knowledge of the characteristics of the different manures.

APPLICATION OF MANURES.

The application of manures is a subject which should receive careful consideration and timely attention from the farmer. Upon the manner in which this part of the work is done will, to a large extent, depend the success or the failure of the manurial treatment. Amongst the points to be considered are the character and composition of the soil, the nature and requirements of the crops, the rotation of crops pursued, the climate of the district in which the farm is situated, and the character and condition of the manure itself.

Application of Dung.

In the application of farmyard manure, simple as the matter may seem, there is great divergence of practice.

Turning Dung-heaps.—Differences of opinion exist as to whether or not it is necessary or desirable to "turn" dung-heaps before applying the manure to the land. This depends mainly upon the manner in which the manure has been made and treated generally during the time it has been accumulating. A certain amount of fermentation is necessary to prepare or "ripen" the dung. Turning promotes fermentation. It is desirable that the dung should be as uniform in texture and character as possible. This may be ensured by turning. Rank, fresh, unevenly made dung, will therefore be improved by being turned over and well mixed two or three weeks before application.

Mr Gilbert Murray says that "in no case is the dung in a fit state for use until the manure in the yards has been turned over and allowed a little time to ferment;" and he adds, that "when treated in this way the liquid manure remaining in the pond should be pumped over the heap."

On the other hand, many farmers and chemists regard the turning process as both unnecessary and injurious. Mr Milne, Mains of Laithers, Aberdeenshire, looks upon the turning of ordinary dung-heaps as waste both of time and of ammoniacal matter. The more dung rots the denser it becomes, and therefore the more difficult to spread evenly on the land, while the unbroken lumps will the longer lie on the land in a useless condition. This, Mr Milne says, any one can verify after a dry summer. If the drills into which the dung had been put are split up, little or none of the fresh dung will be seen, while the rotten dung will turn up almost as solid as when applied. In his part of the country, Mr Milne has not seen a dung-heap turned for twenty years; and if artificial manure is to be used along with the dung, he considers turning quite unnecessary.

In so far as concerns the dung itself, there will, as a rule, be little necessity for turning, provided it has been properly made and taken care of in the cattle-court—that is, if the litter has been evenly distributed (or, better still, cut into short lengths), and well and regularly saturated with urine, so that the dung may come out moderately short and of uniform texture and quality. Indeed, with dung so made and treated, there are strong considerations in support of the contention of many farmers, that it is better to cart such dung right from its original position in the court to the land for distribution.

Carting out Dung.—In many parts of the country the dung is turned, not because the turning itself is considered necessary, but because it is deemed advisable, in order to facilitate work in the busy season of laying down roots, to have the dung carted into heaps on the field some time during the winter, when in these parts there is little other work which can be done by either the men or horses. In reference to this point, Mr George Brown, Watten Mains, Caithness, remarks that it would be impossible for farmers in many parts of the north to put in the turnip crop seasonably without another pair—in some instances perhaps two pairs—of horses, if the dung had all to be carted from the steading at this busy time of the year. He also points

out that if rank fresh dung is once turned before application, it is easier to spread it on the land. This is unquestionably true, provided it is not allowed to become so rotten as to get into the dense lumps referred to by Mr Milne. Thus, while a certain amount of turning and fermentation facilitates the even spreading and speedy action of dung in the soil, excessive rotting may to some extent operate against both. It is certainly very important, in carting out or turning dung, that great care should be taken not to allow fermentation to go too far, as in that case a considerable portion of the valuable plant-food in the manure might be lost. Fermentation may be regulated by compressing the dung when it is too rapid, and by opening up the dung when it is too slow.

Process of Turning.—If a dung-heap in the field is to be turned, a beginning should be made at the end farthest from the head-ridge. The unturned dung-heap slopes a little at both ends, but the turned dunghill should be made of the same height throughout. A dunghill is turned over in a succession of breadths of 3 feet, which affords sufficient room for people to work in; but the first few breadths should be narrower than 3 feet, until the desired height of the turned dunghill is attained at that end. At the centre, the height is lowered to that of the first end, and the last end is heightened to the general level.

There is more of good management in attending to these particulars of turning a dunghill than is at first apparent. A turned dunghill will not putrefy equally when of different heights—the greatest heat will be at the highest part, where the dung will become short and compact, whilst at the shallowest it will continue comparatively crude and unprepared; and such different states of the manure will have different effects upon the crop. In ordinary practice, the uniform height of the dunghill is often miscalculated, and thus the ends still continue lower than the centre. The endeavour to equalise the height by throwing dung from the middle to the ends does mischief, inasmuch as no complete union takes place between the turned dung and that thrown upon it, the two portions remaining in different states, and rising unequally to the graip when thrown into the cart. Besides, trampling the centre when the dung was thrown to the ends, causes it to become harder than the rest of the heap, and so to undergo a different degree of putrefaction. In fact, the whole job is bungled.

Dung, properly speaking, does not ferment, but putrefies.

Intermixing.—The outside and drier portions of the dung are put into the inside of the dunghill, and, where different sorts of dung are met with, they are intermingled intimately. Each dace is cut off, and turned over from the top to the bottom. When the bottom is reached, the earth damped by the exudation from the dung-heap is shovelled up by the men with the square-mouthed shovel, or the frying-pan shovel, fig. 252, and thrown upon the breast of the turned dung.

Fig. 252.—*Frying-pan or lime shovel.*

When straw ropes are met with, they should be cut into small pieces and scattered amongst the dampest parts of the dung-heap. Though the dung-heap is cut into parallel trenches, the dung from the top of the new trench is not thrown down upon the bottom of the former one, like trenching land, but upon the breast of the turned dung, which slopes upwards away from the workers. The advantage of this arrangement is not only that the dung is thereby intimately intermixed and not in separate independent trenches, but that when the dung is carting away, it rises freely with the graip.

Fig. 253 represents an excellent steel graip, such as is used in filling dung, made by Spear & Jackson, Sheffield.

In finishing the dunghill, the men shovel up all loose dung and earth along its sides and ends to the top, and a dung-heap thus turned over forms a parallelopipedon, and is a good-looking piece of work.

Lime-shovel.—Fig. 252 is a frying-

pan shovel, which is so named from its similarity to that culinary utensil. It is also called the lime-shovel, as being well adapted for the spreading of lime upon the land, the raised back protecting the hand from the lime, while the sharp point passes easily under it and makes its way along the bottom of the cart. This shovel is chiefly confined to the Border counties. It makes clean work at everything, and is easily handled.

Fig. 253.—*Steel graip.*

Turning and Putrefaction.—Unless much rain has fallen from the time the dung was led out of the court until the heap is turned, the dung will not be very moist, and not at all wet, but in a good workable state, with a slight degree of heat in it. Any evaporation as yet will contain no valuable material, merely moisture, as decomposition of the dung has not begun. Very little moisture will have come from the heap.

After this turning over, shaking up, and mixing together, which should be quickly done, a heat will manifest itself in the course of a few days. The first putrefaction produces no great degree of heat, as the air is still cool at night, and the largest proportion of the heap consists of cattle-dung, which is slow of putrefaction.

Symptoms of Putrefaction.—The first external symptom of general putrefaction is subsidence in the bulk of the heap, which, in the course of 2 weeks, may contract 1 foot of height. A perceptible smell will then arise from the dung, accompanied with a flickering of the air over it, which is occasioned by the escape of vapour and of gases. By inserting a few sticks into the heap here and there, a heat considerably above that of the hand will be felt, and the relative heat of different parts ascertained; and the greatest heat may be expected at the side opposite from whence the wind comes. The actual degrees of heat may be ascertained by the dung-thermometer.

The substance of the dunghill consolidates uniformly, and a black-coloured liquid oozes out at the ground. If the soil upon which the dunghill stands is soft, the oozing is absorbed by it; but if firm, the moisture remains on the surface, and forms small pools in the ruts of the cart-wheels or open furrows. The leakage is trifling; and much moisture cannot exude from dung derived from courts in which the cattle are supplied with as much litter as keeps them dry and warm.

In some cases dung intended for turnips is twice turned, but the losses by excessive fermentation are now better understood than formerly, and farmers are therefore more careful in the treatment of their dung.

Turning Court Dung.—For potatoes, particularly well-made court dung, which has perhaps been made under roof, and is concentrated rather than rank, is considered by many to give the best results when taken direct from the court without previous turning and applied to the soil. Turning is by most farmers regarded as more necessary for turnips than for potatoes. The riper the dung—that is, if the rotten dung is thoroughly broken and evenly spread on the land—the earlier does it begin to afford nourishment to the plant, which, with the young turnips, is a matter of special importance.

Less Necessity for Turning.—The object of turning, we have seen, is to promote the rotting of the dung. One of the main objects of having the dung well ripened or rotted is to ensure its speedy action after application to the soil. Formerly, before the introduction of more quickly acting manures, there was great necessity for this, as otherwise, on account of the slow decomposition of fresh dung, the crops would be liable to suffer from scarcity of available food in their earlier stages. Now, however, the crops can be efficiently nourished in their youth by highly soluble artificial manures, which are fit for assimilation by the crop as soon as they are applied. Thus more time can be afforded to the dung for decomposition in the soil, so that there is less *necessity* for its prior ripening—less *neces-*

sity for turning, thereby saving labour and lessening the risk of loss by excessive fermentation. See pp. 501-530, vol. i.

Time of Application.—The best time for applying farmyard manure will depend upon a variety of circumstances. Chief amongst these are the character of the soil, the climate of the district, and the crop to be grown.

On very *strong land* in preparation for a root crop, the autumn may be the best time. The dung will thus have more time to exercise its beneficial mechanical influence upon the soil, while summer tillage, which would be detrimental to such land, is avoided. But there is one great obstacle to this practice. Dung cannot be applied until it is made, and the main portion of dung is made during the winter months. Thus autumn manuring is impracticable, except where stock are fed in the house in summer, or where there is on hand a reserve supply of manure.

Southern Practice without Drills.—In many parts, especially in England, the system is as follows: Assuming that the stubble is clean, such manure as exists is carted from the yards after harvest, spread on the land, and turned in with a moderately deep furrow. The land remains without further disturbance throughout the winter. As the root-sowing season approaches, the land is scuffled and harrowed, care being taken not to bring any of the crude soil to the surface. The chief desideratum on such soils, and the great secret of success, is to maintain a finely pulverised seed-bed. The mangel or turnip seeds are in this case sown in rows on the flat surface. In this way the moisture is retained, which is an important consideration under the more arid climate of the south. By careful attention to these details, a braird is almost invariably secured.

With Drills or Ridges.—If the land is to be ridged for the roots, then a somewhat different course must necessarily be pursued. The stubble is broken up by a deep furrow early in autumn. As soon as the land has become mellowed by the rains and frost, the soil is ridged up in the rough. Then when the land becomes sufficiently dry, or should a frost set in, the farmyard manure is carried and spread in the ridges which are split, and the manure covered in at the earliest opportunity. The land remains in this state until the season for sowing arrives. Advantage must then be taken of the first favourable state of the land, when a chain harrow is passed lengthways over the ridges. This has the effect of further pulverising the surface, already reduced by the action of the atmosphere.

Supplemental Manure.—If *artificial manures* are used along with the dung, now is the time to apply them, sown broadcast over the surface. A double mould-board plough is then passed between the ridges, and the fine soil set up and the seeds sown. Great care must be taken not to bring any of the solid soil to the surface. Here the young seeds find a congenial soil in which to vegetate, and a supply of moisture within available distance.

Dunging Light Soils.—The once popular system of autumn manuring on light soils is now discontinued by the best and more intelligent class of farmers. The very process of deeply stirring such soils in the autumn *in warm climates* is a source of much waste. Tillage stimulates nitrification, and the rain-water passing through the soil washes out nitrates, whether in the soil or in the manure, or both. In the south, where the winter is so mild that there may not be sufficient cold to check nitrification, such soils are usually more fertile when broken up in spring.

Northern Practice.—In the northern and colder counties different systems of tillage and manuring are pursued. Here the winter tillage of land for roots is universally pursued, so that the full benefit of the pulverising influence of the winter frosts may be secured. And this is done in these northern parts without incurring any serious loss of nitrates in drainage-water, as the winters are too cold to permit nitrification to proceed. Thus the general plan in the north is to plough land for roots with a deep furrow in the autumn or early in winter, let it lie bare till spring, then cross-plough it, and apply the dung in summer just before the seed is sown, the dung being usually spread in drills. This is the usual practice in Ireland also.

Dung for Wheat.—For wheat, the dung is either spread in the autumn, and

at once ploughed in, or it is spread over the young plant during dry or frosty weather. Mr Gilbert Murray says the best results are obtained by the latter method of application.

Dung for Grass Lands.—In top-dressing grass or meadow land with dung, the general practice is to apply the dung in the autumn. Little or no loss arises through its exposure on the surface.

Surface-manuring.—It is a mistake to bury dung deeply in the soil. Indeed it is now well known that nitrification proceeds in inverse ratio to the depth at which the manure is buried; hence the best results are obtained from farmyard manure when kept near the surface. This system of surface-manuring also benefits the layers of grasses and clovers as well as the young wheat. The alleged waste by exposure to atmospheric influences is now regarded as a popular error.

Mr Gilbert Murray states that he has farmed side by side with men occupying good turnip land, whose practice was to draw out and spread the manure on the prepared land, and turn it in with a shallow furrow. The roller closely followed the plough. Their usual sowing time was the last week in June. The land, having lain three or four weeks, was scuffled, harrowed, and rolled, and the seed drilled 20 inches wide on the flat. A considerable portion of the manure was brought to the surface, yet he says he had considerable difficulty in growing a heavier weight of roots per acre on his 27-inch ridges with the manure carefully covered.

Quantities of Dung per Acre.—The old practice of applying excessive quantities of dung at one time has been shown to be wasteful. On an average of years better results will be obtained by a moderate quantity of farmyard manure, supplemented by a good selection of artificial manures.

So much depends upon soil, system of cropping, and quality of the dung, that to attempt to give definite directions as to what quantities should be applied for each crop might be more misleading than useful. From 8 to 12 tons per acre for roots, and from 15 to 20 tons for potatoes, are general dressings, along with artificial manures, which may cost from 25s. to 60s. per acre additional. In certain cases the allowance of dung would be less, and in other instances more.

Dunging Often and Lightly.—As a rule it is the best plan to dung often, and in moderate quantity at each time. As to this point, Mr Gilbert Murray says: "If the land is worked on the six course, I should divide the farmyard manure into three portions. One I should apply to the root break, supplemented by artificials—phosphates and nitrogen—a second would be spread on the young seeds immediately after the separation of the crop, and the third I should apply to the wheat stubble on the separation of that crop and in preparation for the next cereal.

"I have long been convinced of the folly of applying the whole of the fold-yard manure to the root crop. Repeated doses at short intervals is the most effective system of applying dung."

Unsatisfactory Results from Excessive Dressings.—Mr Murray adds: "For the last twenty years I have carefully watched the effects of stable manure on a kitchen-garden devoted to the production of ordinary garden produce. The extent is under 4 acres. To this has been applied the summer and winter manure of thirty horses. The manure is drawn fresh from the stables, placed in heaps, watered, and turned several times until well rotted, when it is carted on to the land and covered in with a deep spit. I can scarcely conceive a more convincing proof of the unsatisfactory results to be obtained by heavy dressings of farmyard manure alone. The crops are not better than, if so good as, those gathered from the same land twenty years ago. It is true the potatoes grow more tops, and the cabbage and cauliflower are more open than formerly. Light dressings often applied are the most efficient.

"Cabbages and mangels as field crops are gross feeders, and pay for extra dressings."

Economical Use of Dung.—It seems to be well established that dung may be, as a rule, most economically used in moderate dressings, along with judicious mixtures of more quickly acting chemical manures.

Application of Artificial Manures.

In the application of artificial manures there is ample scope for good or bad

management. By the use of these manures all the elements of plant-food may be supplied either together or separately, or as many of them given and as many withheld as may be considered desirable. The subject is therefore one of vast importance, placing in the hands of the skilful farmer far greater possibilities than were within his reach when farmyard dung was the only available manure.

It is especially necessary in the use of artificial manures, that the farmer should most carefully consider the character and composition of the soil, the nature and requirements of the crops, the rotation pursued, the climate of the district in which the farm is situated, and the character of the manure itself.

Elements Absorbed by Crops.—In the first place, it would be well to have in view the amounts of the various ingredients abstracted from the soil and atmosphere for building up the substance of the crops. These have already been shown—see p. 62, vol. i., and p. 90, vol. ii.

These substances are present in soils in various proportions, the quantity of each being dependent on the origin of the soil in the first instance; and secondly, on the prior growth of plants on its surface—the residue left by the decay of these having a considerable influence on the natural fertility of every soil. The majority of these constituents exist in all soils in excess of the quantities required to build up the substance of crops, no matter what system of cropping may be pursued; and therefore the farmer, in order to render his soil fertile, has to supply only those few elements which are deficient in the soil.

Elements to be Supplied in Manures.—The subject of manuring is thus reduced to the supply of an *uncertain deficiency* of one or more of the following substances—viz., nitrogen, phosphoric acid, lime, and potash.

The form, manner, time, and quantity in which these substances are to be applied will manifestly depend on the preceding considerations enumerated in the first paragraph under the above heading—considerations which we shall now examine in detail.

Character of Soil and Manuring.—The character of a soil depends on the proportion in which its proximate constituents, sand, clay, lime, or humus, may be present. If either of these preponderate, then the product is known as a clay, sandy, calcareous, or loam soil. These have all different textures, and consequently vary in their capability of retaining the more soluble manures. Sandy and open porous loams have less power of holding manure than clays or heavy loams. Then the relative fertility of all soils is regulated by the character and composition of the materials of which the soil is made up, whether this material owes its origin to the disintegration of the rock it overlies or is transported.

A Knowledge of Geology useful.—There are few studies that would give better paying results to the farmer than that of geology, as a knowledge of the character of the soils on the various rock-formations would correct many a blunder which occurs when a farmer changes to a new locality. Farm practice must always be modified by the relation of the soil to the underlying strata, and not only this, but the system of manuring must also in so far be regulated by the same considerations.

Manures for Different Soils.—The surface-soil and the general practice as to the application of manures may now be considered. On clay soils the best results are usually obtained from nitrogenous and phosphatic manures—the former having the greater influence; on loams, from phosphatic and nitrogenous manures—the former exercising the greater power; while on sandy soils a combination of nitrogenous, phosphatic, and potassic manures generally gives the best return. Soils intermediate between either of these groups will give results in proportion to the modification of the mixture of manures.

Form of Application for Different Soils.—Then, again, the form in which the manure is applied must depend on the composition of the soil. A sandy soil cannot retain a soluble manure: for it, therefore, it is safest to give nitrogen in the form of fish guano, guano, or other organic matter; phosphates, as bone-meal or slag; and potash, as kainit. Loamy soil will usually give the most satisfactory results from nitrogen in the form of sulphate of ammonia and nitrate of

soda mixed, and one of bones to two of superphosphate; whilst clay will respond most freely to nitrate of soda, and superphosphate, three parts—one of bones and two of slag.

Evidence of the Soil.—But the only evidence which is absolutely reliable as to the immediate manurial wants of a soil is that of the soil itself, as expressed, not in chemical analysis, but in various crops carefully arranged so as to test the available supplies of the different elements of plant-food contained in the land. As to how this evidence may be procured, refer to Ville's remarks on pp. 91-93, and to "Farmers' Experiments," on p. 93, in this Division.

Caution in Applying Bones.—In the application of bones, care must be taken that carbonate of lime is not present in too great a proportion, as, if it is so, the carbonic acid present in the water, instead of attacking the tribasic phosphate of lime, will combine with the carbonate of lime, and form a bicarbonate; also, if the carbonate of lime is deficient, the soluble phosphate will not precipitate, and will escape into the subsoil, or it will combine with iron and form phosphate of iron, which does not readily yield up its phosphoric acid to the plant.

Tillage and Manuring.—In applying artificial manures, it should be borne in mind that the natural source of plant-food is the soil, and that manure is merely supplemental. The farmer should therefore, by careful cultivation, endeavour to prepare these soil ingredients so as to render them available to the plant. The quantity of manure required may thus be, to a considerable extent, influenced by the care bestowed on the tillage operations. With efficient and timely cultivation, a certain amount of manure will produce better crops than would be obtained from twice as much manure with bad, ill-timed tillage. One of the most noteworthy facts demonstrated in the Rothamsted experiments is the great influence which perfect tillage and the keeping down of weeds exercise on the productive power of a soil. Indeed, the application of manures cannot possibly be profitable to the farmer unless the soil be moderately well cultivated, as well as efficiently drained.

Return of Manure on Exhausted Land.—It is often remarked by practical farmers that no soil responds more freely to the application of artificial manure than one which had been previously neglected and partially exhausted. The cause of this is obvious. By the repeated cropping without receiving an adequate return in the shape of manure, this soil becomes exhausted of certain of the elements of fertility, while by the decay of the roots of the crops other elements of plant-food are stored up in increasing quantity. Then, when the neglected land is well tilled and the deficient elements supplied in a suitable manure, the store of fertility is called into action, and the result is a bountiful crop.

Manures for Different Crops.—The form and quantity of manure must be carefully adapted to the requirements of the crop.

Limited Guidance of Experiments.—Many experiments have been carried out for the purpose of determining the best form, kind, and quantity of various fertilisers for the different farm crops; but, as has already been stated, the local circumstances of soil and climate and the customs of farming vary so greatly that the results and lessons of these experiments are not, as a rule, to be relied on as guides beyond the respective districts and conditions in which they have been conducted. The results attained at Rothamsted have most certainly been of great benefit to the agriculture of this country, yet it is well to bear in mind that the circumstances under which these have been carried out differ substantially from the conditions surrounding ordinary rotation farming such as prevails throughout the country. It is thus obvious that farmers cannot with safety resort to these experiments for specific directions as to the manuring of their land.

Value and Uses of Experiments.—With a full knowledge and intelligent conception of his own local surroundings—of the character and condition of the soil, the requirements of the crops to be grown, and the climate of the district—the farmer may unquestionably derive valuable aid in his practice of manuring, by careful study of such experiments as have been carried on at Rothamsted and elsewhere. We have taken care to pro-

vide him with convenient means of studying the results of several of the more important sets of experiments conducted in this country; and here we would specially commend the farmer to peruse the contributions to this volume by Mr Warington, on the Rothamsted experiments; by Mr Jamieson, on the experiments in Sussex and Aberdeenshire; and by Dr Aitken, on the Highland and Agricultural Society's experiments.

Manures for Slow and Fast Growing Crops.—It is important in the practice of manuring that the habit of growth of the different crops should be carefully considered. A slow-growing crop, for instance, should receive different manurial treatment from that which is best adapted to fast-growing crops. A slow-growing crop requires a mixed manure, partly soluble, and the balance coming slowly into action. Wheat, which occupies the ground for a comparatively long period, will, as a rule, be able to obtain from the soil all its mineral ingredients, and therefore a supply of readily available nitrogen seems to be all that is required. Barley, on the other hand, is a plant of more rapid growth, and being shallow-rooted, must have its food ready, and near the surface, to ensure a large produce. Then, the leaf-surface is also important, for a plant is dependent on the soil or the atmosphere for its increase, in proportion to the extent of its foliage.

Soil, Climate, and Manuring.—But a still more important consideration is the bearing of soil and climate upon the weight of the crop. For example, in a dry climate 12 to 15 tons is a very general yield of roots; while in a moist climate and favourable soil the produce per acre will be nearly 30 tons, often indeed as much as 40 tons. Now it would be manifestly absurd to apply the same quantity of manure in these two cases. To the consideration involved here is due the diversity and misunderstanding which frequently arises as to the practice of manuring. About 3 cwt. of superphosphate per acre is usually found a suitable quantity to allow for roots in the south of England, where the yield is generally under 20 tons per acre; but in the north of Scotland, where much heavier crops of roots are grown, this quantity may be increased, with economical results, to at least 5 cwt. per acre, besides, perhaps, some bones and nitrogenous manure.

Rainfall and Artificial Manures.—And the climate, particularly the rainfall, should also influence the form in which a manure is to be applied. Every farmer must have noticed that in a dry season the effect produced by artificial manures is very slight indeed, the more soluble showing better results than insoluble manures. From this it may be concluded that soluble manures are most suitable for a dry climate, whilst the less readily available kinds will give better results over a rotation of crops in a moist one.

These remarks are fully borne out by the practice pursued in different localities. In the north and east, where the climate is moderately moist, the application of artificial manure ranges from 5 to 6 cwt. per acre; while in the west and south-west, where the climate is wet, 7 to 9 cwt. per acre would be nearer the average; 3 to 4 cwt. being usual quantities in the dry climate of the south of England.

Manures for Different Rotations.—The length of the rotation must also be considered in determining the form of manure to be applied. For instance, three years' grass will necessitate a larger application of phosphates in the form of bone-meal or slag. For long rotations the slow-acting manures are employed.

More Frequent Manuring.—But many farmers now consider that it is a mistake to apply to the turnip or other green crop the entire quantity of manure required for a rotation of crops. When one considers the solubility of most of the artificial manures now in use, one can readily understand that the spreading of the manure over the crops of the rotation would result in less loss of fertilising matter, and lead to a more reliable increase of crops on an average of years. Again, the insoluble manures, by their greater specific gravity, must speedily find their way to the subsoil, where they are beyond the reach of the plant at its first period of growth. These considerations would lead the farmer to infer that a moderate dose of soluble phosphates, applied along with the seed, would be most suitable for green crops;

and if nitrogenous manure were considered necessary, then sulphate of ammonia or nitrate of soda could be given with the seed or after singling, or guano might be applied at the time of sowing.

Grass seeds then might receive an application of soluble and insoluble phosphates, along with nitrogenous manure—the mixture being varied according to the intended duration of the grass, whether two, three, four, or more years. Then, again, the corn crops after lea would require another top-dressing of phosphates and nitrate of soda. This method would be specially suitable in a climate subject to heavy rainfall, while as a rule it would be safe and economical for average conditions in this country.

Ratio of Different Ingredients.—On account of the diversity of conditions and influences which have been noticed, it is considered unsafe to attempt to prescribe definite doses of manure. But it may be stated approximately that the *ratio* of the manurial elements for green crops should be about 4 of phosphoric acid to 1 of nitrogen; for oats and barley, 2 of phosphoric acid to 1 of nitrogen; for wheat, 2 of nitrogen to 1 of phosphoric acid; and for grass, 1 of nitrogen to 2 of phosphates and 1 of potash.

Time of Application.—Until recently, artificial manures were generally applied along with the seed. Slow-acting nitrogenous manures may be thus applied, but nitrate of soda, as a rule, gives the best results when not sown till after the braird appears. When a heavy dressing of nitrate of soda is to be given, one-half the quantity should be sown then, and the balance held over for later application.

Nitrate of Soda is the most quickly acting of all nitrogenous manures, and is therefore the best adapted for a late dressing to push on a dragging crop. But in a late wet climate, or rainy season, it may not be advisable to apply nitrate of soda, for it has a tendency to force up a rank growth of straw, thus perhaps making the harvest too late, and so endangering the yield of grain.

Sulphate of Ammonia would be more suitable in these circumstances. Indeed, as a rule, in wet districts, or very rainy seasons, sulphate of ammonia gives better results than nitrate of soda. In dry seasons, and on dry soils, exactly the reverse is usually the case. But sulphate of ammonia is not nearly so well suited for top-dressing as nitrate of soda. A safe method of applying sulphate of ammonia is to mix it with dry fine soil (not ashes, as these might cause loss of ammonia), sow broadcast, and plough in immediately.

Mr Warington remarks that *top-dressing* with nitrogenous manures is especially to be avoided when the soil contains any considerable amount of lime, as loss of ammonia might then occur.

Phosphates may be sown any time during winter or early spring. The usual practice of sowing in the drill, when applied to green crops, has until lately been considered satisfactory; but new ideas have sprung up, and the action of soluble phosphates has become better understood. Yet until further information is obtained as to the benefits derived from a change of practice, farmers would do well not to rashly abandon a custom which has long been pursued with fairly satisfactory results. Farmers might advantageously experiment for themselves on this point. They might make trials of different times of application, and the result would guide them as to the best method to adopt.

Sowing Manure in Drills.—In sowing artificial manures in the drills the following plan is found to work well, the manure, as we have already seen, being conveyed to the land in carts: The loads ought each to contain 20 bushels, and thus in, say, a 20-acre field 8 loads are to be applied. The width of the field is, say, 240 yards, and we divide it into breadths of 60 yards. Two carts full of manure are unloosed in each breadth; and the sowers, one to each drill-plough, are started with a weighed quantity to sow along the drill so many yards. If the drills are 27 inches wide, then to sow 6 cwt. per acre, 21 lb. will sow one drill 200 yards. After the sower ascertains the quantity to take in the hand to effect this, he will have no difficulty in applying the quantity correctly, and he will always have a check when each pair of carts are emptied.

The reason for having the carts in pairs is to save the carrying of manure

long distances. The sower can load-up himself, as the space he will thus have to travel will not be too great. In a field, say, 20 chains long, the carts will be placed, one 5 chains from the top, the other 5 chains from the bottom, about 20 yards away from the face on the prepared land, not in the drills.

Another Method.—Another method, still more precise, is conducted as follows: The manure is sown with a machine, which does three drills at once, and is riddled just before being used, so that there may not be any lumps to interfere with even distribution in sowing. The length of the drills is measured to ascertain the number required for an acre. The quantity for each drill is calculated, and the quantity necessary to sow three drills put into one of the artificial manure bags and weighed on a weighing-machine. A bag for each three drills is laid down at each end of the field, making it very convenient to put into the machine without loss of time, and each three drills in this way get their own exact quantity of manure. The weighing of the bags takes up very little time. They are filled to sight as near the quantity as can be guessed, then lifted on to the machine and adjusted to the required quantity according to the rate per acre.

This system may be considered unnecessarily precise, but the result on the crops has proved that it is worth more than the additional labour, which indeed is very little, when properly conducted.

Sowing Manures by Machines.—The practice of sowing artificial manures by machine is much preferable to sowing by hand, and it is fast coming into

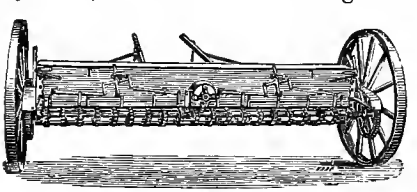


Fig. 254.—*Broadcast manure-distributor.*

favour. By an efficient machine a more even distribution can be secured, and the importance of this is not easily overestimated. Careful consideration certainly shows it to be greater than most farmers seem inclined to regard it. Unless the manure is evenly distributed, its full benefit cannot be obtained, and to secure this, the cost of an efficient manure-distributor would be a good investment. There is still scope for ingenuity in the devising of machines for this purpose, although there are already some very good distributors in existence. One of the best is that made by Ben. Reid & Co., Aberdeen, represented in fig. 254.

The hand-sower "Little Wonder," fig. 263 (p. 195), is also well adapted for sowing dry manures, and so also is Strawson's very ingenious air-power distributor.

Farmers to Judge for themselves.—It might perhaps have been expected that more precise prescriptions would have been given as to the doses of manure to apply for the various crops. Practical farmers, however, know only too well that any attempt to lay down hard-and-fast rules in manuring would be liable to do more harm than good. Doses which give good results on one farm may be quite unsuitable for another.

It has therefore been considered advisable rather to present in a convenient form such information as will enable farmers to become acquainted with the character, purchase, preparation, and application of the various manures, and thus, with a careful study of this information, be qualified to judge for themselves, and adjust their practice to suit their own peculiar plans, circumstances, and environments.

ROTHAMSTED EXPERIMENTS.

Rothamsted has become a household word wherever science is applied to agriculture. In 1834 Sir (then Mr) John Bennet Lawes succeeded to the estate of Rothamsted, Hertfordshire, and soon after began to conduct experiments with different manuring substances, first with plants in pots, and afterwards in the field. In 1840 and 1841 somewhat extensive field trials were carried out, and in 1843 the experiments were begun upon the comprehensive and systematic form which they have ever since maintained. The foundation of the Rothamsted Experimental Station is therefore usually dated from 1843.

The experiments, the most elaborate and comprehensive of the kind ever attempted in any country, have from the first been maintained entirely by Sir John Bennet Lawes, Bart., LL.D.; and with munificent liberality and public spirit he has set apart the handsome sum of £100,000, besides certain areas of land, to ensure to British agriculture the benefits and guidance derivable from the perpetual continuation of the Rothamsted experiments. The unique and splendid inheritance which the country is thus to receive from a private citizen is of priceless value.

Since 1843, Dr J. H. Gilbert has been associated with Sir John Lawes in the conduct of the experiments, and has had the direction of the laboratory. Since 1850, one, two, and sometimes three chemists have been employed in the laboratory; and, as indicating the vast amount of chemical work undertaken, it may be mentioned that in 1887 there were more than 40,000 bottles of samples of experimentally grown vegetable produce, of animal products, of ashes, or of soils, stored in the laboratory.

Besides the experiments upon crops and manures, many interesting points connected with the feeding of farm live-stock have been experimentally investigated, and much of the valuable information thereby acquired has been incorporated in different parts of this work.

For the following sketch of the general scope of the investigations with manures, of the detailed experiments with wheat under different manurial treatment, of the behaviour of manurial substances in the soil, and of the loss of plant-food in drainage-water, we are indebted to Mr R. Warington, who has long been engaged in chemical work at Rothamsted.

The Soil. — Rothamsted adjoins the village of Harpenden. The land lies mostly about 400 feet above the sea. The average rainfall is about 28 inches. The surface-soil is a heavy loam, containing many flint stones; the subsoil is a pretty stiff clay, resting on chalk. The chalk is usually about 9 feet from the surface, and affords a good natural drainage. The land does not bear a high rent. The soil is a fair one for wheat, but would not be considered as specially suited for barley; it is still less suited for turnips. No sheep are kept on the farm. Dairy cows and bullocks are kept on the permanent pasture. The arable land is largely devoted to corn crops.

Scope of the Manurial Experiments. — Different fields on the farm have been set apart for the study of individual crops; thus one has been devoted to wheat, one to barley, one to roots, &c. In each of these fields the crop has, as a rule, been grown continuously for many years without the intervention of fallow or any other crop.

In the early years of the experiments trials were made with various miscellaneous manures, and the same plot of land did not each year receive the same manure, but after a little while the present systematic treatment was adopted. In nearly every case farmyard manure has been annually applied to one portion of the experimental field, while another portion has been left entirely without manure. The other plots have received the various chemical constituents of manure, either singly, or in mixture with each other. The substances applied have been generally—ammonia salts, nitrate of soda, superphosphate of lime, sulphate of potash, sulphate of magnesia, and sulphate of soda. The object has been to supply the various constituents of plant-food (see p. 57) in their most soluble and active form, and thus obtain their greatest effect. By employing substances of known composition, it is also possible to calculate how much of each constituent has been applied to the land.

Each plot of land has, during the later systematic portion of the experiments, received each year, as a rule, the same manure. The system pursued has in fact been to grow the same crop for many years on the same land with the same manure. By this plan trustworthy averages of the amount of produce yielded under each condition of manuring are obtained, and also ample information as to the influence upon the produce of seasons of different character. The permanent or temporary effect of the manures is also shown.

By long-continued treatment of this kind the soil of the experimental field, which was at first practically the same throughout, has been altered, so that the

different plots now represent extremely different conditions of food-supply. On certain plots the crop now grows in soil specially exhausted of nitrogen, or phosphates, or alkalies, to an extent which can very rarely occur in farm practice; while in the soil of other plots abundance of these constituents has accumulated.

The work has not been confined to a determination of the amount of produce obtained from each manure; the crops have themselves been analysed at the Rothamsted laboratory. Information has thus been obtained as to the proportion of the manure that is recovered in the increase of the crop; and also respecting the alteration in the composition of the crop brought about by the differences in the composition of the soil, and the character of the season.

Soil and Drainage-water Investigations.—The investigation has further extended to the soil. After applying the same manure to the same land for many years, it becomes possible to learn by soil analysis what accumulation or exhaustion has taken place, and the depth to which manure has penetrated. In one of the fields the drainage-waters are collected and examined: the nature and amount of the soluble matters lost by drainage, under various conditions of manuring, are thus indicated. The investigations relating to the soil are, from the difficulty of the subject, in a less advanced stage than those relating to the effect of manures on crops.

Scientific Character of the Trials.—It will be seen from the above sketch that the object of the investigations has been purely scientific. It has not been the aim to discover the most economical manuring for each crop. None of the experiments have been designed with a view to a money profit; on very few of them would there be any profit if conducted on a large scale. The whole investigation, therefore, stands condemned by the so-called "practical" man as a mere scientific amusement, from which he has nothing to learn. He, indeed, may learn little, but it will be because he lacks the elementary knowledge which is necessary for an appreciation of the results.

The mode of investigation adopted is, however, one which must add largely to our true knowledge of crops, manures, and soil. This knowledge will be turned to practical account in a number of ways by a skilful farmer; but to provide him with practical rules has not been the object of the investigation. To have made the practical result the chief object, would have cramped the whole inquiry, and defeated its highest purpose.

EXPERIMENTS ON THE CONTINUOUS GROWTH OF WHEAT.

The experiments on wheat are among the oldest of those at Rothamsted. Broadbalk field has been under arable culture for at least two or three centuries. It grew its last turnip crop in 1839: this was followed by barley, peas, wheat, and oats. The last four crops were without manure.

The continuous growth of wheat commenced in 1844, and has since proceeded without interruption, so that the present crop (1889) is the 46th. The cultivation of the land has been that usual in the district; there has been no deep ploughing. The seed used in the first 5 seasons was old Red Lammas; then followed Red Cluster (4 seasons), Red Rostock (29 seasons), Square Head (8 seasons). The area of the full-sized plots (*a* and *b*) is 6-10ths of an acre; there are some half plots. All the artificial manures are sown broadcast, screens being carried on each side of the sowers to prevent the manure falling on other plots. The wheat is drilled in October, 2 bushels of seed being used. In the spring and early summer great care is taken to remove weeds. The luxuriance of weeds, in the absence of fallow crops, will always prove a practical objection to the continuous growth of corn, and especially of winter corn.

Without Manure.

In Table I. is shown the average produce per acre on Plot 3, without manure, in four succeeding periods of ten years, and during the last five years.

[TABLE I.

TABLE I.—PRODUCE OF WHEAT WITHOUT MANURE, FORTY-FIVE YEARS, 1844-88.

	Dressed Corn.		Total Produce.
	Quantity.	Weight per Bushel.	
	bush.	lb.	lb.
Ten years, 1844-53 . .	15¾	58.3	2711
" 1854-63 . .	16½	57.6	2728
" 1864-73 . .	12¾	59.0	1924
" 1874-83 . .	10¼	58.3	1614
Five years, 1884-88 . .	12½	59.7	1648
Mean of forty-five years .	13⅝	58.5	2178

If all the seasons had been perfectly alike, the produce of the unmanured land would doubtless have fallen steadily throughout the experiment — more rapidly at first, and very slowly afterwards. The very variable character of the seasons in our climate prevents any such regularity in the produce. The course of change is best seen by looking at the amounts of "total produce."

The average produce of forty-five years of continuous wheat-growing without manure is seen to be 13⅝ bushels. It is interesting to note that this amount is quite equal to the average yield of the principal wheat-producing countries of the world. Thus, the average yield of the United States is 12 bushels, of Australia 11 bushels, and of India 10 bushels.

With Farmyard Manure.

Ordinary yard manure, at the rate of 14 tons per acre, has been annually ploughed in in October on Plot 2; the produce is shown in Table II.

TABLE II.—PRODUCE OF WHEAT WITH FARMYARD MANURE, FORTY-FIVE YEARS, 1844-88.

	Dressed Corn.		Total Produce.
	Quantity.	Weight per Bushel.	
	bush.	lb.	lb.
Ten years, 1844-53 . .	27	59.8	4828
" 1854-63 . .	37¾	60.3	6355
" 1864-73 . .	35¼	60.8	5797
" 1874-83 . .	29⅝	60.1	5086
Five years, 1884-88 . .	36¼	62.0	5778
Mean of forty-five years .	32⅝	60.4	5546

Plant-food in Dung.—The amount of plant-food supplied is much larger than on any other plot in the field. The fourteen tons of farmyard manure are estimated to contain 201 lb. nitrogen, 235 lb. potash, 35 lb. magnesia, 31 lb. lime, and 78 lb. phosphoric acid, with a number of other substances, including a large amount of silica, which is at present supplied to no other plot in the field. In consequence of this large supply there has been a great accumulation of manurial matter in the soil, which is now far richer than that of any other plot in the field.

Limits to High Manuring. — The

table shows a considerable rise in the produce during the earlier years of the experiment, owing to the accumulation of food in the soil. This rise afterwards ceases. Everything, indeed, in nature tends to come to an equilibrium. On the unmanured land the crop falls, till its demands equal the annual supply from soil and atmosphere. On the dunged plot the produce rises, till here, too, the crop equals the annual supply of assimilable food. With very high manuring we meet with another limit, that of season. A larger crop cannot be produced by manure than the character of the season will admit of.

The average produce with farmyard manure in forty-five years has been 32⅝ bushels; the highest produce was 44 bushels in 1863.

Nitrogen in Dung.—Notwithstanding the richness of the soil, the farmyard manure plot very seldom yields the highest produce in the field, both nitrate of soda and ammonia salts proving more effective. The nitrogen in farmyard manure is in fact principally combined with carbon, and exists as nitrogenous humic matter; only a limited portion of this is each season oxidised, the nitrogen forming nitrates, and thus becoming available to the crop.

Mechanical Influence of Dung.—Not a few of the advantages attending the use of farmyard manure are due to its improvement of the physical condition of the soil. In the present case the soil, while becoming less heavy, has also become more retentive of moisture, and the crop thus suffers less in time of drought (*Jour. Royal Agric. Soc.*, 1871, p. 91). The produce of this plot is more even, and less affected for good or evil by the vicissitudes of season than the other highly manured plots in the field.

With Ash Constituents.

When water has been removed, the constituents of a plant may be classed under two heads—the combustible and the incombustible.

The *incombustible* portion is very small; in wheat grain it is about 1.7 per cent, in wheat straw about 4.6 per cent. It consists of the phosphates, potash, lime, magnesia, silica, &c., derived from the soil.

The *combustible* part is made up of the carbon, oxygen, and hydrogen derived from the atmosphere and rain, and of the nitrogen derived from the atmosphere and soil. The quantity of the principal ash constituents, and of nitrogen, contained in a wheat crop of 30 bushels, has been already given on p. 63.

Of the substances present in the ash, six—potash, lime, magnesia, iron, phosphoric and sulphuric acid—are quite indispensable for plant-growth.

Mineral Theory. — At the time when the Rothamsted wheat experiments commenced, chemists had a very exaggerated notion of the amount of ammonia annually supplied by rain. Liebig, owing to this mistaken idea, taught in 1843 that the ashes of a manure contained its true active ingredients; that where the necessary ash constituents of a crop were supplied by manure, the crop would have no difficulty in obtaining all the nitrogen it required from the atmosphere. This view was known as the "mineral theory." The state of opinion at the time must be borne in mind in considering the Rothamsted field experiments, as they were planned to a considerable extent to test the truth of the mineral theory.

In the first season of the wheat experiments (1843-1844), one plot received 14 tons of farmyard manure, and a second plot the ashes from another lot of 14 tons, with the following result:—

	Dressed Corn.	Total Corn.	Total Produce.
	bush.	lb.	lb.
Farmyard manure, 14 tons .	20½	1276	2752
Ashes of ditto . .	14½	888	1992
Unmanured. . . .	15	923	2043

The plot receiving the ashes thus yielded no more produce than the plot entirely without manure.

Various systematic experiments have since been made with the ash constituents of wheat; these have been supplied in abundance, and the crop left to obtain its carbon and nitrogen from the natural resources of the soil and air.

One plot has received superphosphate of lime only; one a mixture of the sulphates of potash, soda, and magnesia; and one these sulphates together with superphosphate. The latter mixture is termed by Lawes and Gilbert the "mixed mineral" manure. It has generally consisted of 3½ cwt. superphosphate, 200 lb. sulphate of potash, and 100 lb. each of sulphate of soda and magnesia, per acre.

The mixed sulphates of potash, soda, and magnesia, applied for thirty-two years (Plot 1), have not increased the produce at all. Superphosphate of lime applied alone (Plot 0) has, on an average, increased the corn by 3 bushels, and the straw by 2 cwt. The mixture combining both manures (Plot 5) has given an increase of about 2 bushels of corn, and 1¾ cwt. of straw over the produce of the unmanured land.

Nitrogen of the Soil and Atmosphere Insufficient.—As these manures have supplied all the ash constituents of the wheat crop (excepting silica, which we shall presently see to be non-essential), it is quite evident that the amount of the other necessary elements of plant-food supplied by the soil and atmosphere was insufficient to produce a full crop of wheat. The crop grown with a full supply of ash constituents on Plot 5 has contained, on an average, about 20 lb. of nitrogen per acre per annum. This quantity represents the average amount furnished by the soil and atmosphere without the aid of manure.

We shall presently see that the growth of wheat on these plots was really limited by the small quantity of nitrogen at the disposal of the crop. When nitrogen is supplied, phosphates and potash become important elements in producing growth.

Ammonia Salts with Ash Constituents.

The ammonia salts employed have been a mixture of equal parts sulphate and chloride: 200 lb. of this mixture are estimated to contain about 43 lb. of nitrogen. The systematic experiments with ammonia salts did not begin, in several cases, till 1852. We shall therefore take the average produce after this date as the basis of our comparison:—

TABLE III.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF THIRTY-SIX YEARS.

Plot.		Average Produce, 36 Years, 1852-87.				Average Total Produce.		
		Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.	First 18 Years, 1852-69.	Second 18 Years, 1870-87.	Second 18 Years, per 100 of first 18.
		Quantity.	Weight per Bushel.					
		bush.	lb.	cwt.		lb.	lb.	
3	No manure . . .	13	58	11	66.5	2421	1669	68.9
5	Mixed ash constituents	15⅛	58⅞	12⅝	66.9	2786	1944	69.8
6	Do., and ammonia salt, 200 lb. . . .	24	59⅝	21⅞	61.6	4480	3449	77.0
7	Do. do. 400 lb.	32¾	59¾	33¼	56.0	6295	5300	84.2
8	Do. do. 600 lb.	36½	59⅝	40¼	51.5	7152	6518	91.1
10*a*	Ammonia salts, 400 lb.	20½	57¼	18¾	61.8	4018	2788	69.4
11	Superphosphate and ammonia salts, 400 lb. .	25¾	57⅞	24¼	60.1	4936	3758	76.1
2	Farmyard manure, 14 tons	33¾	60¼	31⅝	60.4	6066	5299	87.4

Table III. shows, that whereas the continued use of ash constituents alone increased the crop by only 2⅛ bushels, the addition of 200 lb. of ammonia salts gave a further increase of 8⅞ bushels, the addition of 400 lb. of ammonia salts

an increase of 17⅝ bushels, and the addition of 600 lb. an increase of 21⅜ bushels. The produce with ash constituents and 400 lb. ammonia salts (Plot 7) nearly equals in corn, and exceeds in straw, the produce from the annual application of 14 tons farmyard manure; while the produce with 600 lb. of ammonia salts (Plot 8) considerably exceeds both in corn and straw that yielded by the dung. The far greater effect produced by the nitrogen of the ammonia than by the nitrogen of the dung is very evident, 86 *lb. of nitrogen as ammonia being on a long series of years nearly equal to* 201 *lb. applied as dung.*

Organic Manures Unnecessary.—These results throw a flood of light on the conditions required for producing good wheat crops. The manure applied to these ammonia plots has been purely inorganic, it has contained no carbon; yet the produce has been large, and in favourable seasons very large. In 1863 the yield of corn on Plot 7 amounted to 53½ bushels per acre. About 1 ton of carbon is contained in the average crop of Plot 7, and still more in that of Plot 8. All the carbon assimilated by these crops has been derived from the atmosphere. *The atmospheric supply of carbon is apparently sufficient for the largest cereal crops.* Such crops may be obtained in favourable seasons by the use of purely inorganic manures.

Silica Unnecessary.—The results are equally conclusive as to the uselessness of applying silica in manure. The composition of cereal crops given on page 63 shows silica to be by far the largest constituent of the ash of straw, and to its presence the stiffness of the straw has been too hastily attributed. German experiments have shown that silica is not an indispensable constituent of cereal crops; that fully developed plants can be obtained without it; and that in these plants the straw does not show any want of stiffness.

At Rothamsted, wheat crops, above the average produce of the country, have been continuously obtained for forty years with manures supplying no silica. The produce with these manures has indeed been larger than that yielded by farmyard manure which supplies silica. To make the test still more complete, one-half of several of the plots received for four years an application of soluble silicates, and in the succeeding twelve years the straw of the crop was returned to the land. The half plots thus treated have not shown any increase of produce, save in those cases where the straw was helpful by supplying potash; nor has the wheat-straw any greater power of standing in rough weather than that grown without silica in the manure.

Artificial Supply of Nitrogen essential for Wheat.—The evidence afforded by these experiments with ammonia salts shows unmistakably the great need of the wheat crop for an artificial supply of nitrogen, if full crops are to be continuously obtained. The assimilable nitrogen furnished by the air and rain is quite insufficient for the production of a full cereal crop. The annual application of 86 lh. of nitrogen per acre, in the form of ammonia, has raised the average produce from 15⅜ bushels to 32¾ bushels per acre.

Manures best for Cereals.—The manures which experience has proved to be most effective for wheat, barley, or oats, are those which, like guano, nitrate of soda, and sulphate of ammonia, supply nitrogen in a form readily assimilated by plants. The enrichment of the surface-soil with nitrogen is also the main effect of a variety of agricultural methods commonly employed to render land fit to produce good crops of cereals.

Excessive Dressings Unprofitable.—It will be noticed that the application of 200 lb. of ammonia salts per acre gave an average increase of nearly 9 bushels of corn, and 9¼ cwt. of straw. The addition of a second 200 lb. of ammonia salts gives a further increase of nearly 9 bushels of corn, and 11⅜ cwt. of straw. The 400 lb. of ammonia salts was thus not an excessive dressing. With a further addition of 200 lb. ammonia salts, however, the return is greatly diminished, the increase only amounting to 3¾ bushels of corn, and 7 cwt. of straw. It is plain, therefore, that 600 lb. was not an economical dressing.

For thirteen years, 1852-64, as much as 800 lb. of ammonia salts were applied to one of the plots. The average produce of different amounts of ammonia during these thirteen years was as follows:—

TABLE IV.—PRODUCE OF WHEAT WITH VARIOUS QUANTITIES OF AMMONIA SALTS, AVERAGE OF THIRTEEN YEARS, 1852-64.

Plot.	Manuring.	Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.
		Quantity.	Weight per Bushel.		
		bush.	lb.	cwt.	
5	Mixed ash constituents . . .	18¼	58⅛	16⅝	62.6
6	Do. with ammonia salts, 200 lb. .	28½	58⅞	27⅛	58.8
7	" " " 400 lb. .	37⅛	58¾	38⅛	54.6
8	" " " 600 lb. .	38⅞	58¼	42¾	51.2
16	" " " 800 lb. .	39½	58	46⅝	47.8

We have here a successive increase of 10¼, 8⅝, 1¾, and ⅝ bushels of corn, and 10½, 11, 4⅝, 3⅞ cwts. of straw for each additional 200 lb. of ammonia salts.

High Manuring and Wet Seasons.—It will be noticed that though the crops are larger in this shorter experiment, the return for the second and third addition of ammonia is less than in the longer series of trials. We shall see presently that the nitrogen of the ammonia is liable to be removed as nitrates in the drainage-water in wet seasons. When this happens, the plots receiving an excessive manuring will suffer least; as, notwithstanding their loss, they may retain enough to carry the crop. The explanation of the difference in the two series is therefore apparently to be found in the large number of wet seasons during the latter part of the last thirty-six years.

Corn and Straw from High Manuring.—It will be observed that there is a much larger increase of straw than of corn with the heavier dressings of ammonia salts; the proportion of corn to straw diminishes, indeed, with each addition of ammonia.

The quality of the corn is improved by the use of 200 lb. and 400 lb. of ammonia salts, but with further additions of ammonia the weight per bushel begins to decline.

Ammonia Salts alone.

We come now to Plot 10*a*, which has received annually 400 lb. of ammonia salts, without any supply of phosphates, potash, magnesia, lime, or other ash constituents (saving the sulphuric acid and chlorine in the ammonia salts). This treatment has dated from 1845. The average produce in thirty-six years has been 20½ bushels and 18¾ cwt. of straw; or 7½ bushels and 7¾ cwt. of straw over that of the unmanured land.

Natural Supplies of Ash and Nitrogen.—While the crop on Plot 5 was entirely dependent upon natural sources of nitrogen, the crop on Plot 10*a* has been wholly dependent upon natural sources for its ash constituents. The supply of ash constituents from the soil has clearly been insufficient, for the same amount of ammonia salts, when aided by a manuring of ash constituents (Plot 7), has produced a much larger crop than on Plot 10*a*.

The natural supply of ash constituents, though insufficient, is, however, more effective than the natural supply of nitrogen; for while, on Plot 5, the natural supply of nitrogen only produces 15⅛ bushels, the natural supply of ash constituents is equal to the production of 20½ bushels.

Soils better Supplied with Ash than with Nitrogen.—The fact just stated is one that holds true in general agricultural experience. A purely nitrogenous manure will, in a vast majority of cases, produce a greater effect on wheat or other cereals than any manure supplying ash constituents; not because the latter are less necessary for the growth of the crop, but because the soil is generally far better supplied with available ash constituents than it is with available nitrogen.

It must be recollected also, that the average results obtained in these Rothamsted experiments with purely nitro-

genous manures, are by no means so good as would be obtained in ordinary practice. The soil on Plot 10*a* is now in fact exhausted of ash constituents by forty-four successive wheat crops, removing, at least 900 lb. of potash and 500 lb. of phosphoric acid per acre. In the earlier years of the experiment the ammonia salts applied alone gave a much better result than they do at present.

Importance of Ash Constituents.—The importance of ash constituents when nitrogen is supplied is strikingly shown by comparing the produce of the exhausted soil on Plot 10*a* with that of the soil of Plot 7, which has annually received an abundance of ash constituents, with the same amount of ammonia. The average produce with ash constituents and ammonia is 12¼ bushels greater than with the same quantity of ammonia applied alone. *As nitrogenous manures are by far the most costly that a farmer purchases, it is important to remember that economy in their use depends a great deal on there being a sufficient supply of available phosphates and potash in the soil.*

Ammonia with Individual Ash Constituents.

On Plot 11 the 400 lb. of ammonia salts have been continuously applied with superphosphate. The average produce is 25¾ bushels, and 24¼ cwt. of straw; or 5¼ bushels and 5½ cwt. of straw more than that given by the ammonia salts alone. Thus, on a phosphate-exhausted soil, superphosphate becomes a paying manure for wheat if nitrogen is not deficient.

The produce on this plot is, however, far below that on which *all* the necessary ash constituents are applied. The *superphosphate* has increased the produce of the ammonia by 5¼ bushels, but the *mixture of ash constituents* applied on Plot 7 increases the produce by 12¼ bushels. The mixed ash constituents include potash, soda, and magnesia.

A series of experiments has been made in which the sulphates of potash, soda, and magnesia have been used separately, each with ammonia salts and superphosphate. Unfortunately, previously to the commencement of this trial in 1852, the whole three plots had received during five or six years heavy dressings of potash. It has therefore required a considerable time for the want of potash to affect the amount of produce. Taking, however, the average of the last five seasons, 1884-88, the effect of the special manuring is tolerably apparent, as will be seen from Table V.

TABLE V.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF FIVE YEARS, 1884-88.

Plot.	Manured with Ammonia Salts and Superphosphate.	Total Corn.	Straw and Chaff.	Corn to 100 Straw.
		lb.	lb.	
11*b*	Alone	1323	2019	65.5
12*b*	With soda	1777	2721	65.3
14*b*	With magnesia	1848	2810	65.8
13*b*	With potash	1983	3108	63.8
7*b*	With soda, magnesia, and potash	2130	3322	64.1

The *sulphate of potash* thus yields the largest crop, and its excess over the soda and magnesia will doubtless become more marked as exhaustion of potash proceeds on these plots.

Relative Importance of the Ash Constituents.—*Phosphoric acid* and *potash* are the ash constituents of the greatest importance to the wheat crop, and indeed to every other crop. *Magnesia* is a less important ash constituent of wheat, and is usually found in sufficient abundance in the soil. *Soda* is found to a very small extent in the mature crop; but soda salts have some effect as manure: they probably act by liberating potash in the soil. *Lime* scarcely occurs in wheat grain, and to only a small extent in the straw; the natural supply is quite sufficient.

Effect of Autumn and Spring Applications of Ammonia Salts.

Up to the year 1872, the whole of the manures, with the exception of nitrate of soda, were applied to the land in autumn at the time of wheat-sowing, and ploughed in.

With the season 1872-73, an experiment commenced on the comparative effect of autumn and spring applications of ammonia salts. For five years (1873-77) Plot 15 received 400 lb. of ammonia salts as a top-dressing at the end of March or beginning of April, while Plot 7 received the same amount when the wheat was put in in October. For the autumn of 1877 the manuring was reversed, Plot 15 now received the ammonia salts in the autumn, and Plot 7 received them in the spring. Both plots had at all times a complete autumn manuring with ash constituents.

The comparative results in ten years of autumn and spring manuring are shown in Table VI.

TABLE VI.—COMPARATIVE EFFECT OF AUTUMN AND SPRING SOWING OF AMMONIA SALTS.

	Rainfall.		Drainage, 5-ft. Gauge.		Total Produce, Corn and Straw.		
	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring.	Spring Manuring.	Spring + or − Autumn.
	inches.	inches.	inches.	inches.	lb.	lb.	lb.
1872-73 . .	18.53	6.92	11.45	0.42	3344	5031	+1687
1873-74 .	7.05	7.93	2.89	0.58	7094	4588	−2506
1874-75 . .	10.55	13.55	5.21	3.86	5110	4915	− 195
1875-76 . .	12.17	7.58	10.14	1.94	3793	4083	+ 290
1876-77 . .	22.01	8.18	15.78	1.18	3048	4795	+1747
1877-78 . .	11.17	12.96	8.11	6.02	4486	7017	+2531
1878-79 . .	15.05	17.10	13.09	6.76	1275	4063	+2788
1879-80 . .	5.78	10.82	3.37	1.58	6309	6155	− 154
1880-81 . .	15.20	6.16	12.75	0.25	3489	3917	+ 428
1881-82 . .	10.34	14.73	7.62	4.48	5948	7981	+2033
Mean . .	12.79	10.59	9.04	2.71	4390	5255	+ 865

Spring Sowing preferable.—It appears that, out of the ten seasons, there was one (1874) in which the autumn sowing of the ammonia salts gave decidedly the best result; there were four in which the difference between autumn and spring sowing was very small; there were five in which the spring sowing gave much the best result. The average result was thus decidedly in favour of spring sowing.

Rainfall and Time of Sowing Manure.—When we turn to the other columns in the table, it is plainly seen that the advantage or disadvantage of autumn sowing depends on the amount of the rainfall. The autumn application of ammonia salts is advantageous only when a dry winter follows their application. *This is owing to the fact that ammonia is converted into nitrates in the soil; and the soil, having no power of retaining nitrates, they are liable to be washed into the subsoil by heavy rain, and to be carried in drainage-water beyond the reach of the roots.* This is what happens during a wet winter.

In the table, the quantity of rain, and the amount of drainage-water passing through 5 feet of uncropped soil (60-inch drain-gauge), in each season, is given.

It will be noticed that a wet winter, in some cases (1880-81), does little harm to the autumn-sown ammonia salts. In these cases the wet winter is followed by a dry summer, and the crop is able to draw up from the soil the solution of nitrates which had passed downwards.

The worst results of autumn manuring are when a wet winter is followed by a wet summer (1877-78, 1878-79, 1881-82). In these cases the nitrates washed below

are kept down by the subsequent spring and summer rainfall.

In consequence of these results, the time for applying the ammonia salts to the experimental plots in the wheat-field has been altered. For 1878-83, the ammonia was (save on Plot 15) applied entirely in the spring. Since then 100 lb. of ammonia salts have been applied in autumn and the remainder in spring.

With Nitrate of Soda.

The trials with nitrate of soda commenced in 1852, but the quantities of manure used did not become constant till 1855. We shall therefore quote the results from the latter year. As one object of the experiment was to compare the effect of nitrogen in the two forms of *ammonia* and *nitric acid*, the quantity of nitrate of soda employed was arranged to supply the same weight of nitrogen (86 lb.) as 400 lb. of ammonia salts. The quality of the ammonia salts employed has since improved, so that in later years the quantity of nitrogen supplied as ammonia has probably exceeded by 3 or 4 lb. that supplied as nitric acid. The nitrate of soda has always been applied as a top-dressing at the end of March or beginning of April. The ammonia salts on the comparative plots were applied in autumn, till the season 1877-78.

TABLE VII.—PRODUCE OF WHEAT WITH NITRATE OF SODA AND AMMONIA SALTS, AVERAGE OF THIRTY YEARS, 1855-84.

Plot.	Manure.	Average Produce, 30 Years, 1855-84.				Average Total Produce.		
		Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.	First 15 Years, 1855-69.	Second 15 Years, 1870-84.	Second 15 Years, per 100 of first 15.
		Quantity.	Weight per Bushel.					
		bush.	lb.	cwt.		lb.	lb.	
3	No manure . . .	13	58¼	10⅞	66.9	2390	1670	69.9
5	Mixed ash constituents	15⅛	59⅛	12⅜	68.5	2695	1964	72.8
7	Do., ammonia salts, 400 lb. . . .	33	59⅞	33¼	56.6	6284	5350	85.1
9*a*	Do., nitrate of soda, 550 lb. . . .	37½	59¼	43	49.3	7368	7026	95.3
10*ab*	Ammonia salts, 400 lb.	21¾	57¾	19⅞	62.3	4271	2947	69.0
9*b*	Nitrate of soda, 550 lb.	23½	56⅞	24⅜	53.7	4971	3489	70.2

Nitrate of Soda excels Ammonia Salts.—The nitrate of soda applied alone has given 1¾ bushels more corn and 4¾ cwt. more straw than the corresponding plot receiving ammonia salts. Where an abundance of ash constituents is supplied, as on Plot 9*a*, the advantage from the use of nitrate of soda is still more marked, the excess over the corresponding ammonia plot reaching 4½ bushels and 9¾ cwt. of straw.

As the nitrate of soda, from its well-known solubility, has always been applied in the spring, and the ammonia salts have, in most years of the experiment, been applied in the autumn, the comparison may be thought hardly fair to the ammonia. In Table VIII., the produce by nitrate of soda is compared with that given both by autumn and spring dressings of ammonia salts during ten years, each manure supplying approximately the same quantity of nitrogen, and the land receiving in every case a full supply of ash constituents in the autumn. It will be seen that, on an average, the spring-sown ammonia was 4⅛ bushels better than the autumn sown, and the nitrate of soda 4⅞ bushels better than the spring-sown ammonia. With the straw, the spring-sown ammonia is 5⅜ cwt. better than the autumn sown, and the nitrate 10 cwt. better than the spring sown.

Influence of Rainfall.—Ammonia salts and nitrate of soda compare, however, very differently in different seasons; there are seasons in which the nitrate is

immensely superior, and there are some seasons in which the ammonia salts give an equal or better result. With a dry spring and summer the nitrate is generally much superior to a spring dressing of ammonia salts, the nitrate being immediately available to the plant, while the ammonia has to undergo the process of nitrification, which in dry weather is not speedy. On the other hand, in a wet spring, the nitrate is subject to immediate loss by drainage, while the ammonia is not lost till it is nitrified, and thus for a few weeks partially escapes the losses which the nitrate is undergoing. In Table VIII., the comparative effect of nitrate of soda and ammonia salts is given for the ten seasons of which the rainfall and drainage have been already given in Table VI.

TABLE VIII.—PRODUCE OF NITRATE OF SODA, AND OF AUTUMN AND SPRING SOWN AMMONIA SALTS, IN VARIOUS SEASONS.

Season.	Ammonia Salts, 400 lb.				Nitrate of Soda, 550 lb.	
	Autumn Sown.		Spring Sown.		Spring Sown.	
	Corn.	Straw.	Corn.	Straw.	Corn.	Straw.
			bush.		bush.	cwt.
1872-73	22	18	32⅝	27½	35¾	35⅛
1873-74	39½	41½	29⅛	24¾	38¼	44¾
1874-75	25⅞	30½	25½	28½	30½	42⅜
1875-76	23½	19¾	25½	21¾	33¼	32
1876-77	19⅞	16⅜	33⅛	24⅞	40⅛	34⅜
1877-78	22⅛	27⅜	31¼	44¼	37¼	50¼
1878-79	5⅜	8⅛	16¼	26⅞	22	38⅞
1879-80	36¼	36	34½	35¾	34	39¼
1880-81	25¼	17⅝	26⅝	19⅜	35½	32½
1881-82	29	36½	35¾	51⅛	31⅞	56
Mean	24⅞	25⅛	29	30½	33⅞	40½

It would require a detailed discussion of the character of each season, month by month, if we were to attempt to explain all the differences between the crops; we can only refer to the most striking instances. In 1874, 1876, 1877, and 1881, the nitrate crop exceeds the spring-sown ammonia crop by 7 to 9 bushels, and 10 to 20 cwt. of straw; these are all years in which the spring and summer rainfall are on the whole conspicuously deficient. In 1882 the spring-sown ammonia yields 4 bushels more than the spring-sown nitrate. This year is seen by Table VI. to have had the wettest spring and summer in the series, with the exception of 1879. In 1882, however, a large excess of rain occurred in April; while in 1879 the great excess did not commence till May; the nitrate not yet taken up by the crop thus probably suffered a greater loss in the former season than in the latter. In two seasons, 1874 and 1880, the autumn-sown ammonia salts beat the nitrate in yield of corn. These two seasons have a very dry winter, as well as a dry spring; the rain from spring sowing to the end of June in those two years was but 5.12 and 5.56 inches respectively. The weather during spring was apparently too dry for the nitrate to attain a proper diffusion in the soil. The nitrates from the autumn-sown ammonia were better diffused, and gave the larger produce.

Practical Conclusions.—It is evident from the facts now mentioned that nitrate of soda will give a better return than spring applications of ammonia salts in a dry climate. In a very dry climate the nitrate should be applied very early, or ammonia salts should be employed in the autumn instead. Where the spring months are usually wet, the nitrate should

be applied in two dressings, or recourse had to ammonia salts. When a late dressing is needed, nitrate of soda should be preferred to ammonia salts, as its nitrogen is immediately available. Very late dressings produce straw rather than corn.

Proportion of Corn to Straw.

In Tables III. and VII. will be found the proportion of corn to 100 straw in the produce of the various manures we have considered. The proportion of corn is highest in the produce of the unmanured land, and on that receiving only the ash constituents of the wheat crop.

The addition of any manure producing luxuriance of growth increases the proportion of straw; thus, by the continuous application of farmyard manure, the proportion of corn to 100 straw falls from 66 to 60.

With increasing quantities of ammonia salts, applied with ash constituents, the proportion of corn gradually falls, being 61.6, 56.0, and 51.5, with 200, 400, and 600 lb. of ammonia salts. This considerable increase in the proportion of straw with the higher amounts of ammonia is not, however, entirely due to the ammonia, as on Plot 10*a*, with 400 lb. of ammonia salts alone, the proportion of corn is 61.8; and on Plot 11, with the same quantity of ammonia with superphosphate, the proportion is 60.1 to 100. The increase in straw is clearly due in great part to the potash supplied on Plots 6, 7, and 8, which helps largely to form straw when the nitrogen necessary to nourish the crop is present.

The proportion of straw is much greater with nitrate of soda than with ammonia salts (Table VII.) Here, too, the effect of the ash constituents is seen, for while the nitrate alone gives 53.7 of corn to 100 straw, the proportion when phosphates and potash are added is 49.3 to 100.

Diminution in Produce.

In Tables III. and VII. we have given the total produce of the various plots during the first and second half of the period of experiment. In every instance there is a diminution of produce in the more recent years. The plots receiving the most abundant manuring, as 2, 7, 8, 9*a*, are those which have suffered least in the second period; the diminution in their case varies from 5 to 16 per cent. The smallest diminution takes place on Plot 9*a*, receiving nitrate of soda and ash constituents. In these cases we may probably assume that the decline in produce is due to the inferiority of the seasons in later years.

The produce of other plots, as 3, 5, 10, and 9*b*, shows a diminution of about 30 per cent in the second period. We have here, besides the effect of bad seasons, the still greater effect of the gradually progressing exhaustion of the soil.

Influence of Season.

The 45 successive wheat crops in Broadbalk field at Rothamsted, grown for the most part under the same conditions as to manuring every year, afford splendid material to the statistician for indicating the varying produce of the country in different seasons. We cannot in this place regard them in this wide aspect. The produce of each plot, and the character of each season, during 40 years, will be found in two papers by Messrs Lawes and Gilbert, in *Jour. Royal Agric. Soc.*, 1864, 93; 1884, 391. To these papers, and to a paper, "Our Climate and our Wheat Crops," *ibid.*, 1880, 173, we must refer for full details. We have here to regard the influence of season as a condition affecting the fertility of soil and the action of manures.

Every farmer knows that the effect of season is greater than the effect of manure. A season may be so bad that the best soil and manure may yield a miserable produce, and it may be so good that moderate manuring may nearly equal in result a liberal treatment. A suitable manuring will, however, assert itself in a large majority of cases, redeeming a bad season from utter loss, and securing from a good season the grand return which it is capable of yielding.

Influence of Light and Heat.—No large crop can be obtained without a sufficient amount of light and heat, as the assimilation of carbon from the atmosphere only occurs with suitable light and temperature. The formation of seed especially requires heat. A bulky crop in June will produce abundance of corn in July, if this month is warm, and not

too wet; but it will remain a crop of straw if July is cold and rainy. The corn produced in a cold wet summer is also imperfectly developed; it contains less starch, and a larger proportion of albuminoids and ash constituents, than well-ripened grain, and has a low weight per bushel. The same defect in the corn may be brought about by premature ripening, occasioned by sudden heat and drought; but this will seldom happen upon a clay soil like that at Rothamsted.

Autumn and Winter Weather.—The popular view of the character of a wheat season is confined to the meteorological conditions of spring and summer. Winter is taken into account only when frost or floods have injured the plant. We have already seen, however, when considering the very different results of the autumn and spring application of ammonia salts, that the dryness or wetness of the autumn and winter is a most important factor in determining the character of the next summer's crop. In a wet winter, the nitrates produced in the soil since the last cropping, or resulting from autumn applications of nitrogenous manure, may be removed almost entirely in the drainage-water, and the soil reduced to an impoverished condition by the time the growth of wheat commences in the spring. A dry winter is thus essential if a full wheat crop is to be harvested throughout the country.

The farmer who applies nitrate of soda, ammonia salts, or guano as a spring dressing, may of course make himself independent of the character of the winter; but if the winter has been wet, he must apply more of those expensive manures to produce the wished-for effect.

Conditions Favourable to Large Crops.—The years of greatest total produce during the Rothamsted experiments have been 1863 and 1854. These seasons had dry winters, and in the case of 1863 the winter was also mild. There was also during spring and summer a deficiency of rain, though enough fell at critical times to prevent any check to growth. The summers were not unusually hot, indeed that of 1854 was decidedly cool; there was thus no premature ripening of the produce.

These are the conditions favourable to large produce on every description of soil, manured or unmanured. The dry weather between autumn and spring retains in the soil all the nitrates belonging to it; dry mild weather during winter and spring also occasions a maximum development of root; the plant is thus enabled to levy contributions from a considerable depth of soil. If moderately dry weather continue, the plant is afterwards fed with a concentrated solution of plant-food. The moderate warmth of the season allows full time for the collection of food from the soil. There is finally a somewhat late harvest, and a most abundant produce.

High Temperature.—A different class of good seasons are those with high temperature, and (generally) an early harvest; such seasons were those of 1857, 1868, and 1870. The produce in corn, though very good, is not equal to that of the longer and cooler seasons; and the produce in straw is much less.

Bad Seasons.—The worst possible season is that in which a wet winter is followed by a cold, wet, cloudy summer, as in 1879. Under these circumstances the soil is robbed of soluble food; the whole plant, roots included, is scarcely developed, and, fed with a copious supply of rain-water, a miserable crop is the inevitable result. The most liberal manuring is the one that under these circumstances yields the best return.

The seasons 1853, 1860, 1867, 1871, 1873, 1875, 1876, were bad seasons for the production of wheat, but none were nearly so bad as 1879.

Ash Constituents and the Seasons.—The beneficial effect of giving a good supply of ash constituents with the ammonia salts or nitrate is generally very conspicuous in a season of low vitality, or in one of premature ripening. The bulk of the produce is not affected so adversely by the season, and the grain has a higher weight per bushel where the soil is well supplied with ash constituents.

Effect of Residues of Manures.

As only a portion of every dressing of manure is taken up by the crop in the season in which it is applied, it becomes an important practical question whether

the unused portion of the manure remains in the soil in such a condition as to yield a supply of food to subsequent crops. The subject has recently received additional importance, as, under some circumstances, a farmer has now a property in the unused residues of the manures which he has applied.

The Rothamsted experiments supply numerous illustrations of the influence of the residues of previous manuring. We will, in this place, refer to a few of the most important experiments on this subject occurring in the wheat field. We will consider first the results showing the effect of residues of ash constituents.

Residues of Ash Constituents.—One half of Plot 10, designated 10*b*, received in 1847, and again in 1849, a liberal manuring of ash constituents, containing in all about 300 lb. of potash and 130 lb. of phosphoric acid. The other half of the plot, named 10*a*, did not receive this manure. For the season 1851, and since, both halves of the plot have received annually 400 lb. of ammonia salts without ash constituents.

As manuring with ammonia salts alone is the treatment which produces the most rapid exhaustion of the ash constituents of the soil, it is naturally an excellent means of bringing into view any store of ash constituents which the soil contains.

Table IX. shows the average produce per annum of the two half plots since 1852.

TABLE IX.—AVERAGE PRODUCE OF WHEAT ON PLOTS 10*a* AND 10*b* DURING THIRTY-TWO YEARS.

	Dressed Corn.			Total Produce.		
	Plot 10*a*.	Plot 10*b*.	Excess on 10*b*.	Plot 10*a*.	Plot 10*b*.	Excess on 10*b*.
	bush.	bush.	bush.	lb.	lb.	lb.
Eight years, 1852-59 . .	22¾	27½	4¾	4055	4885	830
" 1860-67 . .	24	27¼	3¼	4076	4563	487
" 1868-75 . .	19	20⅛	1⅛	3060	3264	204
" 1876-83 . .	16⅜	18⅛	1¾	2618	2935	317
Thirty-two years, 1852-83	20½	23¼	2¾	3452	3912	460

The figures show an average annual excess of 2¾ bushels on the plot which received in early years the dressings of ash constituents. The excess was most considerable in the first years, but was still perceptible in 1888.

In thirty-six years the residue of ash constituents on 10*b* has produced in all ninety-one bushels of corn! This is a very striking fact. It must, however, be recollected, that the effect of this *residue of potash and phosphoric acid* is made apparent only by following a treatment very exhaustive to the land, and that such an exhaustive system is very wasteful, and one that it would never pay a farmer to follow. Had ash constituents been regularly applied to Plot 10*b* during the thirty-six years, the same quantity of ammonia would have yielded 340 bushels more corn!

Residue of Ash and Ammonia Salts.—Our next illustration will show not only the effect of residues of ash constituents, but also the effect produced by a previous manuring with ammonia salts. The manures on Plots 17 and 18 have alternated each year since 1852. In each year one plot receives the usual full dressing of ash constituents, and the other plot 400 lb. of ammonia salts. In the following year the manuring is reversed, the plot that had received ash constituents now receives ammonia, and the one which had received ammonia now receives ash constituents. There is thus each year a crop by ammonia salts, plus a residue of ash constituents, and a crop by ash constituents, plus the residue from the ammonia.

The average effect of these annual residues is shown in Table X.

TABLE X.—EFFECT OF ANNUAL RESIDUE OF ASH CONSTITUENTS, AVERAGE THIRTY-SIX YEARS.

	Dressed Corn.	Total Produce.
	bush.	lb.
Ammonia and residue of ash constituents .	30½	5258
Ammonia alone, Plot 10α	20½	3403
Excess, due to residue of ash constituents .	10	1855

EFFECT OF ANNUAL RESIDUE FROM AMMONIA SALTS, AVERAGE THIRTY-SIX YEARS.

	Dressed Corn.	Total Produce.
	bush.	lb.
Ash constituents and residue of ammonia .	15¼	2500
Ash constituents alone, Plot 5 .	15	2365
Excess, due to residue of ammonia . . .	¼	135

The abundant residue of ash constituents remaining from the preceding year has proved its effectiveness, by raising the produce by 10 bushels per year.

We turn now to the result produced by the residue of the ammonia. It has yielded, according to the table, an increase of but ¼ bushel per year!

Of the 86 lb. of nitrogen contained in the ammonia salts, not more than 43 lb. would be contained in the crop obtained by its use; what then has become of the remaining 43 lb.? It is quite clear that the missing ammonia is not present in the soil ready for use in the next season, for it produces no effect on the crop.

We shall see presently that there is much evidence to show that the unused ammonia has been in great part lost as nitrates in the drainage-water.

We have one more instance to give of the effect of residues of ammonia. Plot 16 received for thirteen years (1852-1864) 800 lb. of ammonia salts per annum, with ash constituents. This was the largest amount of ammonia salts applied to any plot in the field. The average produce during these thirteen years was 39½ bushels of corn. From 1865-1883 the plot was left unmanured. The excess of produce in these nineteen years over the produce of the permanently unmanured land is shown in Table XI.

TABLE XI.—EXCESS OF PRODUCE ON PLOT 16 OVER PLOT 3, IN NINETEEN YEARS.

	Dressed Corn.			Total Produce.		
	Plot 3.	Plot 16.	Excess of 16 over 3.	Plot 3.	Plot 16.	Excess of 16 over 3.
	bush.	bush.	bush.	lb.	lb.	lb.
1865	13¼	32⅜	19⅛	1861	5007	3146
1866	12⅛	17⅜	5¼	2046	3081	1035
1867	8⅞	14⅜	5¾	1505	2512	1007
1868	16⅝	22¾	6⅛	2027	3503	1476
Average—four years, 1869-72 .	12¼	15¼	3	1943	2493	550
" eleven " 1873-83 .	10½	11¾	1¼	1613	1821	208

It will be noticed that in the first year after the cessation of the ammoniacal manuring on Plot 16, there was on this plot a considerable crop, exceeding by 19⅛ bushels that of the permanently unmanured land. This considerable excess must be attributed to a residue of the preceding abundant nitrogenous manuring remaining in the soil. In the second, third, and fourth years, the excess of crop on the previously manured soil is only 5 or 6 bushels. After this time the excess rapidly diminishes, averaging in the last eleven years only 1¼ bushel per annum.

It is probable that only the excess of the first year was due to an unused residue of nitrogenous manure. The excess of the later years, we shall see presently, was probably rather due to a gradual oxidation of the accumulated organic matter in the soil.

Practical Conclusion.—We learn, then, that residues of phosphoric acid or potash remain available for future crops, but that no effective residue remains in the soil, even from abundant applications of ammonia salts. The use of such salts is apparently attended with a considerable waste of nitrogen.

EXAMINATION OF THE SOILS.

It may be assumed that, at the commencement of the experiment, the soil of the various plots in Broadbalk field was of a fairly uniform composition, though the subsoils would then, as now, be more or less irregular in character. As on some plots of the field no manure has been applied, while on other plots there have been long-repeated applications of particular manures, the composition of the soil is now of the most varied description. On some of the plots the land is now extremely rich in phosphoric acid and potash, on others it is exhausted of these constituents to an extent which could hardly occur in ordinary farm practice. On some plots nitrogen has accumulated, on others the soil is impoverished.

1. *Contents in Cinereal Plant-food.*

Little has been done in the way of mineral analysis of the soil. Hermann von Liebig examined the soils of some of the plots collected in 1865, and determined the amount of various constituents soluble in dilute hydrochloric and in dilute acetic acid, and the amount of phosphoric acid soluble in nitric acid. His results for the unmanured soil are given in Table XII.

TABLE XII.—SOME CONSTITUENTS IN 100 PARTS OF UNMANURED SOIL (PLOT 3) IN BROADBALK FIELD, 1865.

	Soluble in Dilute Hydrochloric Acid.	Soluble in Dilute Acetic Acid.		
	First 9 inches.	First 9 inches.	Second 9 inches.	Third 9 inches.
Lime	2.298	2.065	.377	not determined
Magnesia	.092	.028	.013	not determined
Potash	.085	.015	.018	.011
Soda	.066	.012	.013	.014
Sulphuric acid	.015	trace	.002	.003
Silica	.434	.065	.080	not determined
Phosphoric acid, soluble in dilute nitric acid	.075	.075	.047	.043

The lime in the surface-soil at Rothamsted is principally due to ancient dressings of chalk. The phosphoric acid originally present in the surface-soil, at the commencement of the experiments, is estimated by H. Liebig as .084 per cent. This he considers as below that necessary for a good wheat soil. He con-

cludes, from his analyses of the soils and subsoils of other plots, that the phosphoric acid which had been applied as manure, and not removed in the crops, was still present in the soil, chiefly in the first 9 inches, but some also in the second 9 inches. Of the potash applied, he found some in the first 9 inches; but a large quantity was not found. He thought it most probable that it had really entered into some insoluble combination which was unattacked by his weak acid. The sulphuric acid, and the soda applied in the manures, had apparently not been retained by the soil.

2. Contents in Total Nitrogen.

The soils and subsoils of the various plots have been on several occasions carefully sampled, and the nitrogen which they contained determined. The last and most complete examination was made on soils collected in October 1881. The amount of nitrogen found in some of the principal plots is given in Table XIII.

TABLE XIII.—NITROGEN FOUND IN FIRST 9 INCHES OF SOILS FROM BROADBALK FIELD, 1881.

Plot.	Manuring.	Average Total Produce per Acre, 1852-81.	Nitrogen in Dry Soil.		
			Per Cent.	Per Acre.	Excess over Plot 5 per Acre.
		lb.		lb.	lb.
3	No manure	2108	0.1045	2404	...
5*a*	Ash constituents	2394	0.1012	2328	...
6*a*	Do. and ammonia salts, 200 lb.	3954	0.1153	2652	324
7*a*	" " " 400 "	5710	0.1264	2908	580
8*a*	" " " 600 "	6778	0.1320	3036	708
9*a*	" and nitrate of soda, 550 "	6903	0.1253	2883	555
9*b*	Nitrate of soda, 550 "	4293	0.1106	2543	215
10*a*	Ammonia salts, 400 "	3450	0.1074	2471	143
10*b*	Ammonia salts, 400 "	3923	0.1077	2476	148
11*a*	Superphos. and ammonia salts, 400 lb.	4387	0.1164	2676	348
2	Farmyard manure, 14 tons	5696	0.1957	4502	2174

The first thing that strikes one in looking at the figures is the smallness of the alteration in the nitrogen of the soil produced either by exhaustive cropping or by very liberal treatment with artificial manures.

Slow Exhaustion of Soil-nitrogen.—On Plots 3 and 5 no nitrogen has been applied; the crop has drawn its nitrogen entirely from the soil and atmosphere. On Plot 5 production has been stimulated as far as possible by liberal manuring with the ash constituents of wheat. In this condition of nitrogen hunger, all the nitrogen has been taken from the soil that could be taken; yet at the end of twenty-nine years the soil still contains 2300 to 2400 lb. of nitrogen in the first 9 inches. The amount of nitrogen lost in twenty-nine years of continuous wheat-cropping without nitrogenous manure is probably not more than one-fifth of the amount originally present in the soil.

The *slowness* with which the nitrogenous matter in the soil is oxidised, and made soluble and available to the plant, is a great natural safeguard against the complete exhaustion and sterilisation of the soil which might else speedily occur under bad treatment.

Small Increase of Soil-nitrogen by Ammonia or Nitrates.—On the other hand, the liberal manuring with ammonia salts, or nitrate of soda, which many of the plots have received, and which has resulted in large crops, has not produced any considerable increase in the nitrogen of the soil. We have already seen that these *nitrogenous manures, though very active in the season in which they are applied, leave no residue in the soil available for the next season; they, in fact, feed the crop but not the soil.*

Soils Enriched in Nitrogen by Heavy Crops.—Though, however, ammonia and nitrates do not themselves

permanently enrich the soil, it will be seen, on comparing the average total produce of the plots during nine years with the nitrogen found in the soils at the end of this period, that there is a distinct relation between the two. *The nitrogen of the soil rises or falls as the previous cropping has been abundant or not.* Thus the same amount of ammonia has been applied on Plots 7 and 10. The former plot, having been well supplied with ash constituents, has yielded a good crop; the latter, having no ash constituents, has given a much smaller produce. The soils now reflect, not the quantity of ammonia applied to them, which has been alike, but the amount of produce grown upon them, the soil of Plot 7 containing considerably more nitrogen than the soil of Plot 10. The soil has in fact been *enriched*, not by the manure, but by the *residue of roots, stubble, and weeds* left in it at the end of each harvest. That this is the case is further proved by the fact that the proportion of carbon found in the various soils rises or falls with the proportion of nitrogen.

The permanence of the percentages of nitrogen and carbon in the soil thus depends on the permanence of the amount of produce. We shall expect a further decline in nitrogen in the soils of Plots 3, 5, 9*b*, 10, and 11, because the crops on these must still further diminish in consequence of their imperfect nutrition; but we do not expect any further decline in Plots 6, 7, 8, 9*a* (unless there should be a series of seasons below the average), because the nutrition on these plots is complete, and the amount of crop and crop residue should remain fairly constant.

Effect of Exhaustive Treatment.—Plot 16, which is not mentioned in the table, affords a striking instance of the rapidity with which a soil falls out of condition when it passes from a liberal to an exhaustive treatment. As already stated (p. 142), this plot received up to 1864 a larger amount of ammonia salts, with ash constituents, than any other plot in the field, and surpassed every other plot in the amount of its total produce. In 1865 the soil was sampled. It then contained in the first 9 inches 2907 lb. of nitrogen per acre, a quantity larger than that found in any other plot (save Plot 2) at that date. From 1864 the soil has been unmanured; the crop, as we have already seen (Table XI.), speedily fell to nearly that of the permanently unmanured soil. In 1881 the soil was analysed again, and found to contain not more than 2557 lb. of nitrogen per acre. The soil had thus lost at least 350 lb. of nitrogen in 16 years, or about 22 lb. per annum.

Residue of Dung.—The soil of Plot 2, receiving farmyard manure every year, is in very different circumstances from those manured with ammonia salts or nitrates. There is here a very large accumulation of nitrogen and carbon in the soil, due, not to crop residues, but to large residues of manure. The amount of nitrogen in the soil is shown by Table XIII. to be much larger than in any other plot in the field. It is indeed nearly double that found on Plot 5, receiving no nitrogenous manure. On Plot 2 the crop for some time steadily increased from year to year (Table II.) This increase of crop has now ceased, and the increase of the nitrogen in the soil has also ceased, or is at least proceeding but slowly. The annual oxidation of organic matter in the soil is now, apparently, about equal to the annual receipt.

In the first 9 inches of soil, manured for 38 years with farmyard manure, the proportion of nitrogen to carbon was found to be 1 : 11. On the other plots in the field the proportion was about 1 : 10. By comparing these proportions with those shown by the original materials supplied to the soil, we see in a striking manner the character of the oxidation which takes place in the soil. In moderately rotted farmyard manure the proportion of nitrogen to carbon is about 1 : 19; and in the roots and stubble of cereal crops 1 : 43. The carbon is thus first oxidised, and a residue of nitrogenous humus remains in the soil.

Nitrogen in the Subsoil. — The second and third 9 inches of the various soils have been examined. They are fairly uniform in their percentage of nitrogeu throughout the field, being apparently little affected either by manure or crop residue. They lie, indeed, to a great extent, out of the sphere of accumulation or oxidation. The percentage of nitrogen in the soil of the second

9 inches is usually 0.07, and the amount per acre about 1900 lb. In the third 9 inches the percentage of nitrogen is about 0.06, and the amount per acre 1600 lb. The proportion of carbon to nitrogen diminishes as we descend, being about 1 : 9 in the second 9 inches, and 1 : 8 in the third 9 inches.

Soil-nitrogen unsuitable for Wheat.—One fact plainly taught by the results given in this section is the uselessness of the ordinary nitrogen of the soil for the wheat crop. The unmanured land contains, to a depth of 27 inches, about 5700 lb. of nitrogen per acre, yet the wheat on this land can barely appropriate 20 lb. per annum, and suffers from nitrogen hunger! *The form of nitrogen that practically acts as food for wheat is nitric acid. The growth of the wheat crop is limited (ash constituents being present) by the amount of nitrates present in the soil.*

3. *Contents in Nitric Acid.*

Determinations of nitrogen present as *nitrates* in the various soils and subsoils of Broadbalk field were made in the samples collected October 10 to 18, 1881. The results are described here, as they fall naturally under the head of soil; but the reader is advised to peruse the next section, on drainage-waters, before considering these results, as the subject will become clearer by so doing.

The composition of the drainage-waters of Broadbalk field proves that nitrates are absent, or nearly absent, during summer time in the soils of those plots which receive no excess of nitrogen in their manure. The same fact is shown by the analysis of various soils at Rothamsted, taken from wheat and barley fields immediately after harvest. At this time, unless heavy rain has lately fallen, the soils are nearly destitute of nitrates. After harvest, nitrates generally appear in considerable quantities in the drainage-waters, the amount depending on the richness of the soil in nitrogenous matter, and the abundance of the rainfall, and is much increased by ploughing. In soils containing an excess of ammonia or nitrates beyond the power of the crop to assimilate—either from the largeness of the application, as on Plot 8, or from the fact that the ash constituents necessary for the assimilation of nitrogen are absent, as on Plots 9*b*, 10, and 11—nitrates are found in the drainage-waters, when the drains run, both in summer time and at harvest.

TABLE XIV.—THE NITROGEN AS NITRATES IN THE DRAINAGE-WATERS OF THE PLOTS IN BROADBALK FIELD, FROM MARCH 1881 TO JANUARY 1882, IN PARTS PER MILLION.

Plot.	March 5, 6, 7, Mixed.	August 30.		Sept. 25.	Oct. 14.	Oct. 23.	Nov. 25.	Nov. 27.	Dec. 7.	Dec. 17, 18, 20, 21, Mixed.	Jan. 9.
		A.M. 6.30.	P.M. 2.3.								
2	5.1	...	...	...	...	...	18.9 [1]	7.1	...	5.8	...
3 & 4	3.4	1.2	0.9	4.7	6.3	8.7	5.4	7.0	5.1	4.1	3.5
5	3.6	1.5	1.4	6.0	8.1	9.5	6.0	7.3	6.3	5.0	3.9
6	3.9	...	1.9	7.0	12.3	13.3	8.5	8.8	7.8	6.2	6.2
7	3.9	...	4.1	...	...	18.5	9.8	11.7	10.9	7.3	7.2
8	5.3	...	...	...	...	23.0	17.1	18.2	16.8	11.2	10.2
9	5.2	...	...	...	...	21.8	12.3	...	13.8	9.4	10.0
10	5.9	20.3	16.1	20.6	21.0	16.2	11.2	14.5	14.0	9.3	9.1
11	5.4	9.0	6.8	10.7	12.6	19.6	12.6	14.9	13.7	9.4	9.4
12	4.8	...	2.3	7.2	9.3	15.2	10.5	11.6	10.2	7.6	7.4
13	4.5	...	2.4	...	9.0	14.5	9.8	11.1	9.3	6.8	6.5
14	5.1	...	...	...	...	15.0	9.7	12.1	9.4	6.8	6.7
15	11.6	...	...	...	...	13.1	66.6 [2]	40.5	34.8	26.4	22.4
16	3.1	...	0.3	...	7.4	8.6	5.1	6.3	4.1	3.4	2.9
17	3.9	1.0	0.4	8.8	9.6	10.7	5.4	6.8	5.6	4.1	3.7
18	3.9	...	...	...	...	11.6	7.5	9.0	7.1	5.6	4.9
19	12.1	...	...	...	...	14.9	19.6 [3]	19.2	10.0	15.6	...

[1] Farmyard manure applied October 27. [2] Ammonium salts applied October 27.
[3] Rape-cake applied October 28.

Nitrates in the Drainage.—Table XIV. shows the amount of nitrogen as nitrates in the drainage-water from each plot in Broadbalk field immediately before and after the sampling of the soil. A blank in the table signifies that no water ran from the pipe: drainage would, however, actually occur in such cases. The thick line indicates the interval at which soil-sampling occurred. The drain-pipes did not run from March 7 till after harvest. The ammonia salts and nitrate of soda were applied to their respective plots on March 12. The spring and summer months were dry. The wheat was cut August 8-11. Immediately after followed a deluge of rain, amounting during the whole month to 5.82 inches. The land was scarified early in September, and ploughed towards the end of the month. The soil was sampled between October 10 and 18, the operation being interrupted by heavy rain on the 14th.

It will be seen that on the first running of the pipes after harvest, the drainage-waters from the plots receiving no nitrogenous manure (3 & 4, 5, 16, 17) contained on an average 1.0 per million of nitrogen as nitric acid; those receiving ammonia salts, with a complete or fair supply of ash constituents (6, 7, 12, 13), contained 2.7 per million; while that receiving ammonia with incomplete ash constituents (11) gave 7.9; and that receiving ammonia with no ash constituents (10) 18.2 per million.

In the first division of plots we may safely conclude that no appreciable amount of nitric acid existed in the upper soil at harvest. In the second division the amount, if any, was very small. In the third division a considerable amount of nitric acid had remained unassimilated all through the summer. Of the plots that did not afford drainage-water in August or September, we may class 9*a*, 14, 15, 18 in the second division, and 8 and 9*b* in the third division.

It is clear that after the soil became saturated with water active nitrification commenced, as with each running of the drains the proportion of nitrates in the water is increased, the maximum being reached on October 23.

Nitrates in the Soil and Subsoil.—We now turn to the amount of nitrogen as nitrates found in the soil: this was determined in the first, second, and third 9 inches. The results yielded by the principal plots is shown in Table XV.

TABLE XV.—NITROGEN AS NITRATES IN WHEAT SOILS VARIOUSLY MANURED, OCTOBER 1881, IN POUNDS PER ACRE.

Plot.	Manuring.	First 9 inches.	Second 9 inches.	Third 9 inches.	Total 27 inches.	Excess over Plots 3 and 4.
		lb.	lb.	lb.	lb.	lb.
3	No manure, thirty-eight years . .	9.7	5.3	2.8	17.8	...
4	No manure, thirty years . . .	9.2	4.0	1.8	15.0	...
16*a*	No manure, seventeen years .	10.6	5.0	2.3	17.9	1.5
5*a*	Ash constituents, thirty years	12.6	7.1	4.6	24.3	7.9
17*a*	Do. do., one year .	10.3	7.5	3.4	21.2	4.8
6*a*	Do. and ammonia salts, 200 lb. .	16.5	7.5	4.7	28.7	12.3
7*a*	Do. do., 400 lb. .	22.8	11.3	5.7	39.8	23.4
8*a*	Do. do., 600 lb. .	21.1	13.9	7.8	42.8	26.4
9*a*	Do. and nitrate of soda, 550 lb. .	19.7	10.0	8.2	37.9	21.5
9*b*	Nitrate of soda, 550 lb. .	16.3	20.1	17.7	54.1	37.7
10*a*	Ammonia salts, 400 lb. .	14.2	11.9	7.3	33.4	17.0
11*a*	Superphos. and ammonia salts, 400 lb.	17.9	9.3	3.6	30.8	14.4
19	Rape-cake, 1700 lb. . . .	14.1	13.0	7.1	34.2	17.8
2	Farmyard manure, 14 tons . .	30.0	15.4	6.8	52.2	35.8

It must be recollected in discussing these results, as in all other results of soil analysis, that the figures can only approximately represent the truth, owing to the impossibility of obtaining a sample of soil that shall exactly represent the whole of the plot.

The first point calling for attention is

the preponderance of the nitrates in the surface soil. Taking the mean of all the plots, save 9*b*, the proportion of nitrates in the first, second, and third 9 inches is as 100, 59, and 31. This is owing to the fact that *nitrification takes place chiefly near the surface*, where the soil is richest in nitrogenous matter, and most freely exposed to air. After a continuance of rainy weather, the nitrates would be found much more evenly distributed.

On Plot 9*b*, manured with nitrate of soda only, the nitrates are most abundant in the subsoil. Here a considerable part of the nitrate applied in spring has not been assimilated by the crop, owing to the poverty of the soil in ash constituents: it has remained in the soil all the summer, and reached by drainage and diffusion a lower depth than the nitrate newly formed after harvest.

Nitrates in Soil without Nitrogenous Manure.—The three unmanured plots yield an average of 16.9 lb. of nitrogen as nitric acid per acre in 27 inches of soil. With a liberal supply of ash constituents this is increased to 22.8 lb. It is now known that phosphates favour nitrification; their effect will only be perceived by comparison with a soil exhausted of phosphates.

Nitrates, where Ammonia Applied.—With an annual dressing of 200 lb. ammonia salts, with ash constituents, the nitric nitrogen rises to 28.7 lb. When the ammonia is doubled, or an equivalent quantity of nitrogen as nitrate of soda is employed, the nitric nitrogen becomes 39.8 and 37.9 lb.

With an excess of ammonia salts (600 lb.) the nitric nitrogen reaches 42.8 lb. With an excess of nitrate of soda it is 54.1 lb. The plot receiving ammonia without ash constituents shows a comparatively small amount of nitrates in the surface-soil, the crop and weed residue here being relatively small.

Nitrates from Farmyard Manure.—The largest amount of nitrification in the surface-soil occurs on the plot receiving farmyard manure. The first 9 inches contains 30 lb. of nitric nitrogen per acre; in 27 inches the total is 52.2 lb. The large amount of nitrogen in this soil has been already noticed in the preceding section.

Sources of the Nitrates in the Soil.—Before leaving this section we will recapitulate what has been already said in various places as to the sources of the very considerable amounts of nitrates found in these wheat soils. The nitrates are in some cases (Plots 3, 4, 16, 5, 17, 6) entirely derived from the oxidation of the nitrogenous organic matters of the soil, consisting primarily of crop and weed residues, and the dead bodies of insects and other animals; for it should not be forgotten that the soil of our fields is a burial-ground. On other more highly manured plots the nitrates are mainly derived from a similar source (which in many cases is much more considerable, as the growth on the land has been much greater), but there is, in addition, more or less nitrate which has resulted directly from the ammonia or nitrate applied, and which has existed as nitrate all through the summer. There is, farther, on Plots 19 and 2, but especially on the latter, nitrate derived from the oxidation of organic manure.

The quantities of nitrates found in October in these Broadbalk soils must be considered as decidedly above an average, the large rainfall in August producing a specially early and vigorous nitrification.

Losses by Autumn and Winter Drainage.—As an example of the serious losses which soil may suffer from autumn and winter drainage, it may be mentioned that before the spring of 1882 there had been removed in drainage from these plots of Broadbalk field a quantity of nitrates equal to from one-half to three-quarters of that shown by the analyses in Table XV.

DRAINAGE-WATERS AND THE NITRATES OF THE SOIL.

In order to understand fully the facts shown by the drainage-waters, we must say a word, in the first place, as to the composition of the rain falling on the soil.

Rain-water.—The rain is collected at Rothamsted in a gauge having an area of 1-1000th of an acre. The nitrogen as ammonia which it contains amounts to 2.4 lb. per acre per annum; the nitrogen as nitric acid to barely 1 lb. The chlorine is 14.4 lb., equal to 24 lb. of common salt. The sulphuric acid is

equivalent to 17.3 lb. of sulphuric anhydride per acre per annum. The amount of organic nitrogen has been determined in some samples of Rothamsted rain-water by Dr E. Frankland. If we take this amount as expressing the average composition, the total combined nitrogen in the rain-water becomes a little over 4 lb. per acre per annum. The nitrogen in rain is thus small in quantity, while the chlorides and sulphates are rather considerable, and equal or even exceed the amounts present in most farm crops.

The Drain-gauges.

Since 1870, the amount of drainage has been determined at Rothamsted by means of three drain-gauges, of the respective depths of 20, 40, and 60 inches, and of the area of 1-1000th of an acre. The soil which they contain is in its natural state of consolidation, the gauges having been constructed by cutting under the soil, and then isolating the block of soil by building round it with brick and cement. The soil has been kept free from weeds. No manure has been applied.

Evaporation and Drainage.—The proportion of the rainfall which passes through a soil depends, if there is no surface drainage, entirely on the amount of evaporation that takes place from the surface. The amount of drainage is, in fact, the amount of rainfall minus the amount of water evaporated. The evaporation is of course much greater in summer than in winter. It is also much greater from a soil covered by a crop than from bare soil.

Periods of Drainage.—In an average season comparatively little drainage occurs in the seven months March to September. The period of active drainage is the five months October to February. With land bearing a crop the amount of summer drainage will be still further reduced, and the autumn drainage commence somewhat later.

Chlorides in Drainage.—Since May 1877, the amount of chlorine, and the amount of nitrogen as nitrates, have been systematically determined in the mixed drainage of each month. Average results for 11 years are given in Table XVI.

TABLE XVI.—THE AMOUNT OF DRAINAGE, AND THE NITROGEN AS NITRATES IN THE DRAINAGE-WATER, FROM UNMANURED BARE SOIL, 20 AND 60 INCHES DEEP, AVERAGE OF ELEVEN YEARS.

	Rainfall.	Amount of Drainage.		Nitrogen as Nitrates.			
				Per Million of Water.		Per Acre.	
		20-Inch Gauge.	60-Inch Gauge.	20-Inch Gauge.	60-Inch Gauge.	20-Inch Gauge.	60-Inch Gauge.
	inches.	inches.	inches.			lb.	lb.
March	1.60	0.78	0.88	7.5	9.0	1.33	1.80
April	2.31	0.82	0.90	8.2	8.9	1.53	1.82
May	2.50	0.69	0.70	9.0	10.3	1.40	1.63
June	2.40	0.66	0.66	9.5	9.7	1.42	1.45
July	2.50	0.52	0.45	15.4	13.3	1.81	1.35
August	2.67	0.85	0.76	15.9	14.0	3.05	2.40
September	2.88	1.07	0.91	17.8	13.5	4.32	2.78
October	3.26	1.97	1.77	14.1	12.1	6.30	4.83
November	3.26	2.48	2.36	11.8	11.4	6.64	6.13
December	2.48	1.97	1.96	9.4	10.6	4.19	4.72
January	2.14	1.82	1.98	7.3	8.7	3.00	3.91
February	2.31	1.99	1.87	7.6	9.0	3.41	3.80
March–June	8.81	2.95	3.14	8.5	9.4	5.68	6.70
July–September	8.05	2.44	2.12	16.6	13.6	9.18	6.53
October–February	13.45	10.23	9.94	10.2	10.4	23.54	23.39
Whole year	30.31	15.62	15.20	10.9	10.6	38.40	36 62

The amount of chlorides found in the water from the drain-gauges, when calculated as pounds per acre, is found to be practically identical with that furnished by the rain. The soil in the drain-gauges has thus apparently been thoroughly washed out, and all residues of soluble manure removed.

Nitrates in Drainage.—The quantity of nitrates in the water from the drain-gauges is very large, amounting in the drainage from 20 inches of soil to 38.4 lb., and in the drainage from 60 inches of soil to 36.6 lb. per acre per annum. Of this quantity only about 4 lb. could possibly be supplied by the rain; the remainder has come from *the oxidation of the nitrogenous organic matter of the soil.*

Nitrification and Bacteria.—Nitrification in soil is now known to be accomplished by the agency of a bacterium. This requires for its action the presence of water; the ash constituents of plant-food; a salifiable base, as carbonate of lime, with which the nitric acid may combine; a suitable temperature; and the presence of sufficient oxygen in the surrounding atmosphere. Ammonia is apparently the substance which is oxidised into nitric acid.

The first stage in the nitrification of the nitrogenous humic matter of soil is probably the production of ammonia. This production of ammonia is also apparently the work of bacteria, but whether of the same species which produces nitrification is at present unknown.

Consistently with these conclusions, based on laboratory experiments, it is found that nitrates are produced most abundantly in moist soils, during warm weather, and that the production is greatly increased by tillage, and that ammonia salts, when mixed with a fertile soil, are rapidly converted into nitrates.

Discharge of Nitrates in different Months.—On looking at the amounts of nitrogen as nitrate found in the monthly drainage from the soils of the drain-gauges, it will be seen that the smallest amount is found in March. After this month the strength of the drainage-water slowly rises. In July a great stride is made, and the drainage-water in this month has sometimes the maximum strength for the year, though on an average the maximum is a little later. The largest quantity of nitrates is not, however, discharged till the season of active drainage commences in October. After November the amount discharged in the drainage-water diminishes, the soil being gradually washed out.

Nitrification does indeed continue during winter time (probably not in actual frost), but with far less activity than in summer. From the 20-inch drain-gauge, 61 per cent of the nitrates annually discharged are expelled in the drainage of five months—October to February. The proportion for the same period with the 60-inch gauge is 64 per cent.

Total Production of Nitrates in the Soil.—The 36-38 lb. of nitric nitrogen discharged on an average each year from the drain-gauges, may be regarded as representing the average annual production in the soil. The rate of production is apparently diminishing, the easily oxidised nitrogenous matter contained in the soil becoming slowly exhausted. We shall see, by-and-by, that the rate of production in a manured soil, or in a bare fallow subject to tillage, is considerably greater.

Loss per Acre.—The significance of these results is at once apparent, when we recollect that *the amount of nitrogen as nitrates present in a soil represents the amount of nitrogen available as plant-food for most crops.* These nitrates are annually produced in the soil, and they are lost with great ease by drainage. The money value of nitrogen in nitrate of soda is, at the present price of this salt (£11 a ton), 7½d. a pound. The 38 lb. annually lost by the uncropped soil of the drain-gauge are thus worth 24s. an acre, and this sum would have to be spent in manure to replace the waste by drainage, if the fertility of the soil is to be maintained.

The Nitrates in Fallow Soils.

As the soils of the drain-gauges represent a bare untilled fallow in an exhausted soil, it will be most convenient to mention here the amounts of nitrogen as nitrates found in ordinary farmed soils at Rothamsted at the end of a season of bare fallow. Three analyses of soil, taken in September or

October, from different fields, in fair agricultural condition, showed 56.5, 58.8, and 59.9 lb. of nitrogen as nitrates per acre, in 27 inches from the surface. When the preceding summer had been dry, the principal part of this nitrogen (40 lb.) was found in the first 9 inches.

In bare fallows, on unmanured and exhausted land, 33.7 and 36.3 lb. of nitrogen as nitrates were found.

All these amounts represent the quantity left in the soil at the end of fourteen or fifteen months fallow. If we estimate the probable amount lost by drainage during the seasons in question, it will appear that about 80 to 90 lb. of nitric nitrogen had been produced per acre in the better soils during the period of fallow.

The Nitrates in Cropped Soils.

The determinations of nitric acid in soils that have just grown a cereal crop show a very small amount existing in the soil. On permanently unmanured wheat land there was found, after harvest in 1878, only 2.6 lb. of nitrogen as nitric acid in the first 9 inches, and no determinable quantity in the second 9 inches. The same land was sampled again in March 1881 (it had been left unploughed through the winter)—it then contained in the first 27 inches 14.5 lb. of nitric nitrogen.

In September 1877, after a good crop of barley, grown with nitrate of soda, 15.7 lb. of nitric nitrogen were found in the first 9 inches of soil, but in 45 inches below this depth only 6.2 lb. The nitrate at the surface had probably been formed in great part since the active growth of the crop had ceased.

The nitrates found in the wheat plots of Broadbalk field have been already noticed in detail; in this case the sampling of the soil did not take place till the middle of October, after heavy rain, and the ploughing of the land, had caused vigorous nitrification to take place.

The Drainage-waters of Broadbalk Field.

The principal plots of Broadbalk field consist of two "lands," each 4⅛ yards wide, and forming the two halves, *a* and *b*, of the plot. The length of the plots is 352 yards. Under the furrow, in the middle of each plot, is a drain-pipe, laid in 1849, at from 2 to 3 feet below the surface. Since 1866 the lower end of each pipe has discharged into a small pit, so that the drainage-water can be collected from the end of the pipe. The series of pits are connected by a large cross-drain which keeps them free from water. There is no means of gauging the quantity of water discharged from each plot, nor would any measurement give a correct idea of the amount of drainage, as much drainage must occur through the soil itself.

Run of Water in different Months.—There is no continuous run of water from these pipes. The discharge ceases soon after the cessation of rain. The dates on which each pipe has run since 1866 have been recorded. As an example of the distribution of the discharge throughout the year, we will take the case of the pipe from the unmanured land, Plots 3 and 4. This pipe has discharged in July, August, and September, only on nine, six, and eight days respectively during twenty years. In October active drainage commences, 35 daily runnings occurring in twenty years. In November the runnings reach 59, and in December and January 60 and 61. In February there is a diminution, the total being 42. In March the runnings are only 18, and the monthly total still further diminishes as summer is approached.

Heavy Crops and Drainage.—On those plots which bear the heaviest crops the runnings are less frequent in spring and summer, and begin somewhat later in autumn.

Farmyard Manure and Drainage.—The drain-pipe from the plot receiving farmyard manure runs less frequently than any other. This is apparently due (at least in part) to the greater power of retaining water possessed by the soil of this plot. Determinations made in January 1869, when the soil of the field was saturated with water, showed that in the first 3 feet, the soil continuously manured with dung contained 214 tons more water per acre than the permanently unmanured land.

1. *Ash Constituents lost in Drainage.*

Several series of drainage-waters collected in 1866-68 were analysed by Dr

Voelcker. Other series, collected in 1868-73, were analysed by Dr E. Frankland. Since 1876, determinations of the nitrates and chlorides have been made at the Rothamsted laboratory, in nearly every running, or in mixtures of the runnings, of every pipe. The subject is a large one. We can only here dwell on the points of greatest practical importance; further details will be found in *Jour. Royal Agric. Soc.*, 1874, p. 132; 1881, p. 1.

We will, in the first place, call attention to some facts shown by the analyses of Voelcker and Frankland. The following table gives the mean of five analyses by Voelcker and five by Frankland, of the drainage-waters from the principal plots.

TABLE XVII.—MEAN OF TEN ANALYSES OF BROADBALK DRAINAGE-WATER BY VOELCKER AND FRANKLAND, 1866-73, IN PARTS PER MILLION.

Plots.	Total Solid Matter.	Lime and Magnesia.	Chlorine.	Nitrogen as Nitrates.
3 & 4	228	99	10.4	3.9
5	330	132	10.7	4.7
6	450	171	23.5	9.0
7	542	207	33.9	15.9
8	615	222	44.8	20.2
9	406	126	12.4	16.0
10	442	173	37.1	17.6
11	490	197	38.6	19.4
2	367	123	19.4	11.5

Unmanured Plot Drainage.—The drainage from the permanently unmanured plots, 3 and 4, is seen to have contained 228 of solid matter per million of water; the principal constituents of this solid matter are lime salts, chiefly the carbonate.

Ash Constituents Plot Drainage.—The superphosphate, and the sulphates of potash, soda, and magnesia applied to Plot 5, considerably increase the contents of the drainage-water, the solid matter rising to 330 per million. The sulphate of lime in the superphosphate, and the sulphate of soda, are the chief constituents of the manure which appear in the drainage-water. The sulphates of potash and magnesia do not appear directly in the drainage-water, but by acting on the lime in the soil, they contribute a further quantity of sulphate of lime to the drainage.

Ammonia Salts and Drainage.—When ammonia salts are applied to the land, the quantity of matter removed in the drainage-water is much increased. Thus the application of 400 lb. of ammonia salts alone to Plot 10 raises the solid matter to 442 per million. When ammonia salts are added to the ash constituents applied on Plot 5, the solid contents of the drainage-waters rise in proportion to the quantity of ammonia salts added. Thus in the drainage-waters from Plots 6, 7, and 8, to which 200, 400, and 600 lb. of ammonia salts are applied, the proportion of total solid matter is respectively 450, 542, and 615 per million.

The ammonia salts used in these experiments are composed of equal parts sulphate and chloride. The solid matter which they remove from the soil consists chiefly of the *sulphate*, *chloride*, and *nitrate of lime*.

Ammonia Salts robbing a Soil of Lime.—The whole of the sulphuric acid and chlorine contained in the ammonia salts probably combines with the lime of the soil. The nitric acid produced by the oxidation of the ammonia will also unite with lime, and if not appropriated by the roots of the crop, the nitrate of lime will also appear in the drainage-water. This action of ammonia salts in impoverishing a soil of lime must be borne in mind whenever their application to a soil poor in lime is in question.

Nitrate of Soda and Lime.—The nitrate of soda applied on Plot 9 has ap-

parently little or no influence in increasing the proportion of lime in the drainage-water. As only one-half the plot receives ash constituents, the amount of lime applied as manure is one-half that received by Plot 5. Although receiving some lime in the manure, the quantity present in the drainage-water is considerably less than in the water from Plot 10, receiving ammonia salts without lime.

Lime and Magnesia lost in Drainage.—For the purpose of illustrating the annual losses of lime and magnesia[1] which the soil suffers by drainage, we will assume that the average annual drainage in Broadbalk field amounts to 10 inches (2¼ million lb. per acre), and that it has the composition shown in Table XVII. The lime and magnesia annually lost by the unmanured Plots, 3 and 4, will then be 223 lb.; by Plot 5, receiving only ash constituents, 297 lb.; by Plot 9, receiving nitrate of soda and half a dressing of ash constituents, 284 lb.; by Plot 10, receiving 400 lb. of ammonia salts alone, 389 lb.; by Plot 11, receiving 400 lb. of ammonia salts with superphosphate, 443 lb.; and by Plots 6, 7, 8, receiving, on an average, the same manure as Plot 11, with the sulphates of potash, soda, and magnesia in addition, 450 lb. per acre. As the quantity of lime and magnesia in the annual dressing of ash constituents is only 104 lb., the amount lost is greatly in excess of that applied to the land.

These results are good examples of the losses of lime occurring both on unmanured and on manured land. The necessity of restoring lime to many soils after a number of years is well known.

Phosphoric Acid in Drainage.—The amount of phosphoric acid found by Dr Voelcker in the drainage-waters was very small; the average of all the determinations is 0.93 per million. With 10 inches of annual drainage, this would amount to a loss of 2.1 lb. per acre.

Potash in Drainage.—The drainage-water from six plots receiving no potash in their manure contained, on an average, 1.6 of potash per million; the waters from eight plots receiving potash contained an average of 4.2 per million. The former proportion would, with the drainage previously assumed, correspond to a loss of 3.6 lb., and the latter to a loss of 9.5 lb. per acre per annum.

It must be recollected, however, that both potash and phosphoric acid would, in the absence of drain-pipes, be retained in great part by the subsoil.

Soda in Drainage.—Soda is shown by Voelcker's analyses to be present in much larger quantity in the drainage-water. The water from six plots receiving no soda as manure contained a mean of 6.1 of soda per million. The water from five plots receiving 100 lb. of sulphate of soda, gave 11.6 per million. Where 366½ lb. of sulphate of soda are applied (Plot 12), the amount became 24.6 per million. Where 550 lb. of nitrate of soda were used (Plot 9), the soda is increased to 56.1 per million.

These results illustrate the well-known fact that soil has a far less retentive power for soda than for potash. The soda in the drainage from the unmanured land was probably derived from rain.

Chlorine and Sulphuric Acid in Drainage.—The chlorine and the sulphuric acid in the manures are not retained by the soil, but appear freely in the drainage-waters.

Drainage from Dunged Plot.—The scanty drainage from the farmyard manure plot (2), though much stronger than that from the unmanured land, is by no means so concentrated as that from many plots receiving artificial manure. It is, according to Voelcker, specially rich in sulphuric acid.

2. *Nitrates Lost in Drainage.*

We turn now to the part of the subject which, in recent years, has been most thoroughly investigated at Rothamsted—namely, the loss of nitrates in the drainage-waters.

Not only the nitrates, but also the *chlorides* removed in the drainage have been determined. From the results relating to chlorides many valuable facts have been learnt. Indeed, without the information which they afford, our interpretation of the course of action which takes place would be uncertain or imperfect. We shall here, however, confine ourselves as far as possible to the results relating to nitrates.

[1] The magnesia shown in Voelcker's analyses is small in amount, generally 4 to 5 per cent of the lime.

Unmanured Plot.—We take first the case of the wheat land which is left permanently without manure. Table XVIII. shows the average monthly proportion of nitrogen as nitrates, and of chlorine present in the drainage-waters.

TABLE XVIII.—NITROGEN AS NITRATES AND CHLORINE IN THE DRAINAGE OF UNMANURED WHEAT LAND, AVERAGE OF EIGHT YEARS, 1878-86.

	Runnings of Drain-pipes (Days).	Per Million of Water.		Nitrogen to 100 Chlorine.
		Nitrogen as Nitrates.	Chlorine.	
March	7	2.0	4.5	43.5
April	10	1.9	4.3	
May	6	0.8	3.3	12.7
June	8	0.1	2.9	
July	4	0.0	1.7	5.2
August	6	0.2	2.4	
September	5	3.9	9.0	50.8
October	20	4.9	9.3	
November	25	3.2	6.7	61.1
December	26	5.0	6.8	
January	14	3.2	4.8	67.3
February	34	4.1	6.1	
March–May	23	1.6	4.1	39.3
June–August	18	0.1	2.4	4.5
September–November	50	4.0	8.0	49.8
December–February	74	4.3	6.1	69.6
Whole year	165	3.4	6.0	55.8

Loss of Nitrates Checked by Crop.—The nitrates in the drainage-waters from the uncropped soil of the drain-gauges increased in proportion as the spring advanced, and the waters attained their maximum strength between July and September. Here, on the land bearing an unmanured wheat crop, the nitrates diminish as the spring advances, and soon entirely disappear. In fact, out of the 18 collections of drainage-waters made during eight years in June, July, and August, there were only two which contained any nitrate.

The nitrates are thus entirely removed from the upper 2½ feet of soil (the depth above the drain-pipes) during the period of active growth of the crop.

Loss Resumes when Crop is Removed.—After the crop has been removed from the land, the first drainage-water collected is sure to contain nitrates. The proportion rapidly increases, and, if the season is wet, a maximum is reached in October. Nitrification diminishes in energy as the weather becomes colder, and the amount of nitrate in the water diminishes to some extent, but is fairly maintained till after February, when the nitrate is once more taken up by the new crop.

The course of change shown in the table is not regular, because in some of the seasons drainage did not commence till winter, and the maximum strength of the water was consequently postponed.

The *chlorine* in the drainage-water is derived from rain. It is permanently assimilated by the crop to only a small extent. The relation of nitric nitrogen to chlorine thus serves to indicate the formation or removal of nitrates in the soil.

Dung Plot.—The nitrates in the drainage from the plot annually manured with farmyard dung show the same course of change that we have just noticed. The average results of fifty runnings during eight years were as follows.

The farmyard manure is ploughed in in October:—

TABLE XIX.—NITROGEN AS NITRATES IN THE DRAINAGE OF WHEAT LAND RECEIVING FARMYARD MANURE, AVERAGE OF EIGHT YEARS, 1878-86.

	Runnings of Drain-pipes (Days).	Nitrogen as Nitrates, per Million.
March–May . .	4	2.9
June–August . .	5	1.2
September–November	15	8.2
December–February .	26	5.8
Whole year . .	50	5.8

The drainage is seen to be considerably richer in nitrates than that from the unmanured land, but it is by no means as rich as we should expect from the very large amount of nitrogenous manure applied. We shall refer to this point again.

Ammonia Salts.—We turn next to the behaviour of ammonia salts. These, as used at Rothamsted, are a mixture of equal parts chloride and sulphate. When these salts become mixed with the soil they are speedily decomposed, the chlorine and sulphuric acid combine with the lime of the soil, forming soluble salts which can be removed by rain, while the ammonia is retained near the surface in combination with the hydrous silicates, the humus, and the ferric oxide of the soil.

If, therefore, drainage occurs immediately after the application of the ammonia salts, much chlorine and sulphuric acid are found in the drainage-water, with some ammonia, but there is no considerable increase in the quantity of nitric acid. After a few days the nitric acid in the drainage is much increased, while the chlorides have begun to diminish.

We may quote, as an illustration of what we have been saying, some analyses of the drainage-water of Plot 15 made in the autumn and winter of 1880-81. 400 lb. of ammonia salts were applied to this plot on October 25, 1880, and then ploughed in. Heavy rain occurred on the night of the 26th, and the drain-pipe was found running the next morning. The analyses of the drainage-waters are given in Table XX.

TABLE XX.—COMPOSITION OF THE DRAINAGE-WATER OF PLOT 15 BEFORE AND AFTER THE APPLICATION OF AMMONIA SALTS ON OCT. 25, 1880, IN PARTS PER MILLION.

Date of Collection.	Nitrogen as Ammonia.	Nitrogen as Nitrates.	Chlorine.	Nitrogen as Nitrates to 100 Chlorine.
1880, October 10 . . .	none	8.4	22.7	37.0
1880, October 27, 6.30 A.M. .	9.0	13.5	146.4	9.2
" " 1 P.M. . .	6.5	12.9	116.6	11.1
" " 28 . .	2.5	16.7	95.3	17.5
" " 29 . . .	1.5	16.9	80.8	20.9
" November 15, 16 .	none	50.8	54.2	93.7
" " 19, 26 . .	"	34.6	47.6	72.7
" December 22, 29, 30 .	"	21.7	23.2	93.5
1881, February 2, 8, 10 . .	"	22.9	19.4	118.0

The occurrence of ammonia in the Rothamsted drainage-waters is unusual. It is only present in any distinct quantity when, as in this instance, heavy rain follows immediately after applying the ammonia salts.

It will be observed that the nitric acid began to rise in the drainage-water forty hours after the application of the ammonia salts, and in three weeks it reached its maximum proportion. After the middle of November the nitrates steadily declined, but not so rapidly as the chlorides. The proportion of nitrogen to chlorine thus continued to increase throughout the winter.

When ammonia salts are applied as a top-dressing in spring, they are, from the drier character of the season, less liable to the rapid removal of their constituents into the drainage-water.

Relation of Manure to Loss of Nitrates.—The relation of the character of the manuring to the contents in nitrates of the drainage-waters from the principal plots in Broadbalk field, is shown in Table XXI., which gives the average composition of the drainage-waters in four seasons of the year. The first period is from the top-dressing of the ammonia salts and nitrate of soda in March till the end of May. The second period is from the beginning of June till harvest. The third is from harvest to the autumn sowing of the wheat, when farmyard manure and rape-cake are ploughed in on their respective plots, and ammonia salts applied to Plot

TABLE XXI.—NITROGEN AS NITRATES IN DRAINAGE-WATERS FROM VARIOUSLY MANURED WHEAT LAND, AVERAGE OF FIVE YEARS, 1878-83, IN PARTS PER MILLION.

Plots.		Spring Sowing to end of May.	June to Harvest.	Harvest to Autumn Sowing.	Autumn Sowing to Spring Sowing.	Whole Year.
3 & 4	Unmanured	1.7	0.1	5.6	3.9	3.5
5	Ash constituents . .	1.7	0.2	5.6	4.5	3.9
6	Do., ammonia salts, 200 lb. .	8.1	0.7	7.3	4.8	5.0
7	" " 400 lb. .	16.3	1.4	8.3	5.2	6.4
8	" " 600 lb.	21.5	4.0	14.7	7.3	9.3
9*ab*	" nitrate of soda, 550 lb. .	48.4	9.1	14.3	6.8	12.3
10	Ammonia salts, 400 lb. . .	28.6	11.4	11.5	6.3	9.9
11	Superphosphates, ammonia salts, 400 lb.	19.5	5.8	9.2	7.1	8.5
15	Ash constituents, ammonia salts, 400 lb.	5.7	2.9	7.4	26.4	19.4
19	Rape-cake	4.7	0.5	8.2	12.5	10.1
2	Farmyard manure . . .	2.7	1.4	7.4	7.3	5.6

15. The fourth period embraces the winter months, from autumn sowing to the spring top-dressing.

Only fairly general runnings of the drain-pipes are taken into account, so that the comparison between the plots may be as accurate or possible. The numbers given for Plots 2 and 19 are, however, the average of but 45 and 53 analyses respectively, in place of 78 to 87 in the case of the other plots, as the drain-pipes of the two plots first named ran but seldom.

The general change in the amount of nitrates with the season of the year has been already discussed in the case of the drainage-water from the unmanured plot. We may now confine ourselves to the influence of manure.

With the application of *ash constituents* to the soil (Plot 5) there is some increase in the proportion of nitrates over that produced without manure, but no change in the general character of the drainage.

Looking next at Plots 6, 7, and 8, which receive rising quantities of *ammonia salts* with ash constituents, we see that they are all liable to suffer loss of nitrates in the spring period, after the top-dressing of the ammonia salts in March, the loss being greatest on Plot 8, where most ammonia is applied. Notwithstanding the very considerable amount of nitrate produced from the ammonia salts, it is usually found to have disappeared entirely from Plot 6, and to have disappeared, or have been reduced to a very small quantity, from Plot 7, when the drains run in summer time. Plot 8 receives nitrogen in excess of what the crop can assimilate. The nitrates here do not disappear in summer, though the quantity is greatly diminished.

In a very mild early spring, as that of 1882, the nitrates may disappear from Plot 6, and be reduced to little more than a trace on Plot 7, by the first week in May. In other seasons a similar di-

minution may not occur till June or July.

When the drains commence running after harvest, Plot 8 shows signs of the existence of nitrate that has remained unused through the summer; but the excess of Plots 6 and 7 over Plot 5 is but small.

The winter drainage shows a surprising equality, the amount of nitrates removed from Plots 5, 6, and 7 being more equal than the total nitrogen contained in their surface-soils.

Excess Nitrogen Lost in Drainage.—The results afforded by Plots 10 and 11 are most instructive. The same quantity of ammonia salts is applied here as on Plot 7, but on Plot 10 without ash constituents, and on Plot 11 with superphosphate only. The result is that on these plots, and particularly on 10, the crop is unable to assimilate the nitrogen supplied. The nitrates consequently are found in considerable quantity all through summer, and a distinct residue remains after harvest. *The winter drainage, however, generally removes all excess, and the crop starts the next spring no richer for the unused nitrate of the previous year.*

Winter Application of Ammonia Salts Ruinous.—On Plot 15 the ammonia salts which are applied on Plot 7 in the spring are here applied in October; the salts are not top-dressed, but ploughed in. The winter drainage is here extremely rich in nitrates, and as no crop is then growing, the losses are often extremely heavy. On an average of five years, the drainage-water has contained for the whole year 19.4 per million of nitric nitrogen, as compared with 6.4 in the case of Plot 7, where the ammonia is applied in March.

Practical Conclusions.—These results furnished by the drainage-waters explain in a striking manner the results already shown by the crops. We have now no difficulty in understanding why a spring dressing of ammonia salts is in most seasons superior to an autumn dressing. The reason why the unused nitrogen of an abundant application of ammonia salts produces no effect on the crop of the following season is equally manifest. In both cases the conversion of the nitrogen of the manure into soluble nitrates, and their removal from the soil in the drainage-water, affords an ample explanation.

Nitrate of Soda.—There is but one plot (9) on which we have the results of the direct application of nitrates. The numbers given for the nitric nitrogen should be compared with the mean of Plots 7 and 10, since one half of Plot 9 receives ash constituents and compares with 7, and the other half receives none and compares with 10. Thus viewed, the loss of nitric nitrogen on Plot 9 is seen to be much greater than that of ammonia salts applied at the same time. It is evident, indeed, that the nitrate is ready for removal directly it is applied, while in the case of ammonia, time must be allowed for nitrification.

For this reason *nitrate of soda* is always *applied in spring* to a growing crop, which can at once commence the assimilation of the manure. Notwithstanding, however, the larger loss to which nitrates are liable, so active is the manuring power of nitrate of soda, that, as we have already seen, it actually produces more effect upon the crop than the same quantity of nitrogen applied as ammonia.

A part of the efficacy of nitrate of soda is doubtless due to the fact that it leaves an alkali in the soil, while ammonia salts leave an acid.

Nitrogenous Organic Manures.—The composition of the drainage-waters from Plots 2 and 19, to which organic nitrogenous manures (farmyard manure and rape-cake) are applied, does not fairly compare with the results given by the other plots, as these drain-pipes run much less frequently. These organic manures, from their slower nitrification, accumulate nitrogen in the soil during the earlier years of their application.

The soil thus enriched with nitrogenous matter produces nitrates more evenly throughout the year than soils to which ammonia salts are applied once in the season. This, however, will scarcely prove an advantage when land is cropped with cereals, as nitrates will be freely produced in autumn and winter when there is no crop to appropriate them.

The *rape-cake* contains nearly the same amount of nitrogen as 400 lb. of *ammonia salts*. According to the figures in

the table, the drainage-water contains for the whole year an average of 10.1 of nitrogen per million. This is much less than the autumn-sown ammonia salts, which give 19.4, but more than the spring-sown ammonia salts, which show 6.4 or 9.9, according as ash constituents are applied or not.

The *farmyard manure* plot shows a much smaller quantity of nitrates in the drainage-water than we should expect from the large amount of nitrogen in the manure, and especially from the large amount of nitrate found in the soil in autumn by direct analysis (Table XV.)

Nitrogen Evolved as Gas.—It seems very probable that a considerable part of the nitrates produced on the farmyard manure plot are afterwards destroyed, and the nitrogen evolved as gas. This action is now well known to agricultural chemists. It takes place in soils rich in organic matter, and ill provided with air. It will thus chiefly occur when the soil is for some time saturated with water.

3. *Do Drain-pipes Increase the Loss?*

In concluding this survey of the losses suffered by drainage, it may fairly be asked: Would the losses have been as considerable if the field had not been provided with drain-pipes, especially with pipes so near to the surface as 2½ feet? The amount of water passing downwards through the surface-soil would, of course, be the same whether pipes were present or not. All that the pipes have done is to remove a portion of the drainage-water before it had passed below 2½ feet of soil. If the nitrates that have passed below 2½ feet of soil may afterwards be of service to the crop, then the action of the drain-pipes has tended to diminish the food-supply, and increase the amount of waste.

Influence of Subsoil Nitrates.—The influence of subsoil nitrates on the crop must depend very much on the character of the spring and summer. If these are warm and fairly dry, the crop becomes vigorous, extends its roots, and evaporates through its leaves much more water than is then supplied to it by rain. Under these circumstances a part of the nitrates that have passed into the subsoil in winter will move upwards, and be consumed by the crop. This recovery of nitrates undoubtedly takes place in seasons in which the period of drainage has been short, and the depth to which the nitrates are carried is therefore not considerable.

On the other hand, the recovery, after long-continued rain, must be very small, the nitrates being carried below the possible action of the roots.

Thus in good seasons the drain-pipes may rob the crop to some extent, while in very wet seasons they do not really diminish the supply of soluble food, while they make the crop more vigorous by removing the excess of water.

Nitrates in Deep-well Waters.

We can only here just refer to an investigation concerning the drainage-water which exists at great depths in the soil—namely, in deep wells. The chalk-well waters at Rothamsted and Harpenden have been subjected to a monthly examination, extending over two or three years. The unpolluted well-water, at depths from 60 to 140 feet below the surface, is found to be of nearly uniform composition. *It contains* 4.4 *of nitrogen as nitrates, and* 10 *to* 11 *of chlorine per million of water. This is the final result of the drainage from a large area of land under pasture and arable.* Analyses of 109 pure well and spring waters, from various geological formations, gave Dr E. Frankland a mean of 3.8 nitric nitrogen and 16.5 of chlorine.

Taking the higher figure of 4.4, the loss of nitrogen will be 1 lb. per acre for each inch of drainage. With the lower figure of 3.8, the loss will be 0.86 lb. per inch. Assuming the average drainage for England, excluding the extreme western counties, as 8 inches per annum, we have 8 lb. of nitrogen as the annual loss by drainage, according to the evidence of the chalk wells, and 6.9 lb. as the loss calculated from Frankland's analyses. The loss from arable land will be, of course, much greater than this, while that of pasture will be less, the figure given being clearly a mean of all.

The average loss of nitrogen by drainage is thus distinctly greater than the amount supplied to the land by rain, but it is probably less than the whole atmo-

spheric supply, including the amount absorbed by soil and crop.

NITROGEN STATISTICS—THE SUPPLY, AND WHAT BECOMES OF IT.

The nitrogen contained in the crops removed from the Rothamsted wheat-field is approximately known. The quantity of nitrogen applied as manure is also known. We have also information as to the nitrogen in the soil, and as to the nitrogen removed in the drainage-waters. Is it possible, putting these facts together, to tell what has been the supply of nitrogen to the unmanured crops, and what has become of the nitrogen applied as manure? The problem is one of the highest interest, and Messrs Lawes and Gilbert have attempted to answer it.

Unfortunately the data at command are in part insufficient. The gains and losses of the soil are not exactly known. The composition of the water from the drain-pipes does not certainly indicate the general composition of the water percolating through the soil. The amount of drainage in Broadbalk field is also uncertain, save during the winter months. The figures, therefore, that we have to give, must be taken only as probable estimates, founded upon the facts at command.

Wheat without Nitrogenous Manure.—The unmanured wheat crop has in thirty years contained an average of 18.6 lb. of nitrogen; the estimated loss of nitrogen by drainage is 10.3 lb.; or 28.9 lb. in all have been removed from the land each year. On Plot 5, receiving only ash constituents, the average nitrogen in crop is 20.3 lb., and in drainage 12 lb.; total, 32.3 lb. On these plots the nitrogen in the soil has considerably diminished; the estimated diminution in the case of Plot 5 is about 20 lb. per annum. There is thus left about 10 lb. of nitrogen to be supplied annually by the seed, the rain, and by direct absorption from the atmosphere. If any reduction of nitrates to nitrogen gas has occurred, the supply from the atmosphere would have to be proportionately increased.

Wheat with Ammonia.—The plots receiving ammonia salts all show an unaccounted for loss of nitrogen. The simplest case is that of Plot 7. The ammonia salts have supplied 86 lb. of nitrogen. Assuming, as above, 10 lb. of nitrogen from seed, rain, and air, we have in all 96 lb. to account for. The average nitrogen in the crop has been 46 lb.; the estimated loss in drainage 31 lb.; the total is thus 77 lb., leaving about 19 lb. not accounted for.

This is a simple case, as there is no evidence of any serious change in the nitrogen of the soil during the experiment. The quantity shown as unaccounted for is very probably below the truth, as with a larger crop we should expect an increased supply of nitrogen from the atmosphere.

On Plot 8 and on Plot 10, where the ammonia is present in excess of the capacity of the crop to assimilate it, and the quantity of nitrate passing downwards is very considerable, the quantity of nitrogen unaccounted for in crop and drainage is much larger than on Plot 7.

Wheat Annually Dunged.—The farmyard manure annually applied to Plot 2 is estimated to contain 201 lb. of nitrogen. The average crop during thirty-eight years would contain about 46 lb. of nitrogen. The amount lost by drainage is very uncertain, but it is probably not more than 17 lb. There is further to be taken into account a large gain in the nitrogen of the soil, amounting to perhaps an average of 42 lb. per annum; much more in the earlier years, and much less in the later ones. We have here an average of at most 105 lb. of nitrogen accounted for out of 201 lb., plus that contributed by seed, rain, and air received. The average loss thus appears to be about 106 lb. per annum; much less in the early years of the application, and much more in recent years.

Nitrogen Disappearing.—It will be observed that where nitrogenous manure is applied, there is generally a considerable proportion of the nitrogen which is not accounted for, either in the crop, the soil, or the drainage-water. It is quite possible that the estimates of the loss by drainage are too low. It is difficult, however, to believe that there is not some other source of loss, an action, in fact, which reaches its maximum on the plot annually receiving farmyard manure.

This action is most probably the reduction of nitrates to nitrogen gas.

The serious losses of nitrogen which attend the continued abundant use of farmyard manure is a fact of great practical importance.

The waste of manure with high farming must always be proportionately greater than when smaller crops are aimed at.

In addition to the fruitful investigations thus reported upon by Mr Warington, many important experiments have been conducted at Rothamsted. Amongst the other subjects experimented upon are the manuring of other farm crops, the feeding of stock, the manurial value of foods, the practice of ensilage, and other matters of interest to the farmer. In various parts of this work we have drawn freely upon the great stores of knowledge which have been accumulated by Sir John Lawes and Dr Gilbert, and which they have with characteristic public spirit placed so fully at the service of their fellow-agriculturists.

The results of the experiments on barley, roots, potatoes, and leguminous crops will be referred to when we come to treat of these respective crops. Here it may be useful to present the following summary of some of the

Practical Conclusions

which may be drawn from, or are further confirmed by, the investigations at Rothamsted as to the behaviour of various manures in the soil, and the loss in drainage-waters of nitrates and other elements of plant-food.

That when nitrates—which are formed by the agency of a bacterium—exist in an uncropped soil, they are very liable—indeed in a wet season certain—to be washed away in drainage-water.

That nitrates are produced most abundantly in moist soils, and during warm weather, their production being greatly increased by tillage.

That nitrification—the production of nitrates—continues, though less actively, during mild weather in autumn and winter, ceasing in times of frost.

That there is little danger of serious loss of nitrates in drainage-water while the soil is covered with vegetation.

That it is therefore found advantageous, when there is any considerable residual nitrogen in the soil, to sow some forage crop, such as rye, in the autumn after the removal of a cereal crop, so that the growth of the plants may absorb the soluble nitrates; this forage crop being, perhaps, pastured by sheep, and ploughed down in spring.

That, for the above reasons, the system of bare fallow facilitates the loss of nitrogen in drainage.

That lime and magnesia are liable to be washed out of soils in drainage-water.

That the action of ammonia salts tends to impoverish a soil of lime.

That neither phosphoric acid nor potash is liable to serious loss in drainage.

That soils have a far stronger retentive power for potash than for soda.

That the chlorine and sulphuric acid supplied in the manure are not retained in the soil, but freely pass away in the drainage-water.

That the continued application of farmyard manure tends to lessen the discharge of water from drains by increasing the capacity of the soil to retain moisture.

That the loss of nitrates is prevented by a growing crop.

That immediately on the removal of a crop, any surplus nitrates remaining in the soil, and the nitrates resulting from fresh nitrification, begin to pass away in the drainage-water.

That this washing away of nitrates will go on till the soil is robbed to a great extent of its available nitrogen.

That when ammonia salts are mixed with the soil they are speedily decomposed, the chlorine and sulphuric acid, combining with the lime of the soil, forming soluble salts, which can be removed by drainage-water, while the ammonia is retained near the surface in combination with the hydrous silicates, the humus, and the ferric oxide of the soil.

That, therefore, if drain-water begins to flow immediately after the application of ammonia salts, much chlorine and sulphuric acid and some ammonia are washed away, and that after a few days the rate of loss of nitric acid on drainage becomes very serious.

That when ammonia salts are applied

as a top-dressing in spring, they are, owing to the drier season, less liable to the rapid removal of their constituents in the drainage-water.

That when more nitrogen is applied than can be assimilated by the crop to which it is given, the whole of the excess nitrogen remaining in the soil in the form of nitrates, after the removal of the crop, is generally washed away in winter drainage, so that the next crop starts in the following spring no richer for the unused nitrates of the previous year.

That, in wet seasons, it is ruinous to apply ammonia salts in winter.

That ammoniacal manures should be applied in spring, so as to be speedily used by the crop.

That nitrate of soda is even more liable to rapid loss by drainage than ammonia salts, for the former is ready for removal directly it is applied to the soil.

That, therefore, nitrate of soda should always be applied in spring to a growing crop which can at once commence to assimilate the manure.

That farmyard manure and rape-cake enrich the soil with nitrogenous matter.

That this, however, is not entirely advantageous, as from this store of nitrogen nitrates are freely produced, and washed away in drains in autumn and winter, after the removal of the crop.

That nitrates washed into the subsoil by rain-water, are only partially serviceable to the crop.

That the seed of grain, rain-water, and the atmosphere, contribute to an unmanured wheat crop about 10 lb. of nitrogen per acre per annum.

That where nitrogenous manure is applied there is generally a considerable proportion of the nitrogen which is not accounted for either in the crop, the soil, or the drainage-water.

That the missing nitrogen most probably passes away into the atmosphere in the form of nitrogen gas.

That there is from this cause a serious loss of nitrogen where farmyard manure is applied abundantly.

That the risks of loss are reduced to a minimum, by giving only as much nitrogen as will supply the wants of the crop to which it is to be given, and by applying the manure when the crop is ready to commence the assimilation of it.

That with excessive or abundant manuring the waste of manure will always be proportionately greater than with moderate manuring.

EXPERIMENTS ON PHOSPHATIC MANURING.

Their History, Development, and Results.

In 1875 there were at Rothamsted no experiments showing the relative effect of different forms of phosphates; and, other subjects fully engaging attention, the question has not there been taken up, or at least not largely, to the present time. Yet the annual expenditure for phosphatic manurial matter was then, as now, very great indeed, while the many forms of phosphate available varied greatly in price. It was a source of great national and individual loss if the most effective and economical form was not the one generally used, and unfortunately no distinct information existed as to the relative values of the different forms.

Unless, however, private enterprise took the matter in hand, it seemed that nothing would be accomplished. The private station at Rothamsted was fully engaged with other matters. There were, no doubt, two large and wealthy agricultural societies—the Royal Agricultural Society of England, and the Highland and Agricultural Society of Scotland; but they also were fully engaged on other matters, more in sympathy with the views of their members—such as competition in cattle-rearing, and in implements for mechanical cultivation—and these societies were not encouraged to enter upon elaborate experiments by the fact that the little which had been done in that direction had not fulfilled expectation.

That such experiments did not come up to expectation was due to a want of the development and continuance of the experiments: they were too limited, and too desultory to reach the profitable point. Work that had no outward show, and in its first stages no tangible benefit, could hardly be expected to appeal to

those with whom the whole subject was not only more or less a mystery, but was indeed looked at rather with suspicion. This suspicion was engendered both by the feeling that artificial manure was a departure from the old-fashioned idea of substantial and solid manuring in the form of dung, and also by the feeling that the result of artificial manuring was evanescent, if not positively hurtful. This, in fact, farmers had probably actually experienced, not being all so well trained in agricultural science as to distinguish between suitable and unsuitable manure, nor to perceive that perfect artificial manure is natural plant-food, and that while there were evanescent and hurtful forms, there might also be more reliable and economical forms.

It was not therefore surprising that all appeals made by advanced members of these societies that experiments should be performed, fell on unsympathetic ears; while there was also a tendency to point to Rothamsted as already doing all that was necessary, although, as has been stated, the points were actually not touched there which the farmer really required to know.

ABERDEENSHIRE EXPERIMENTS.

It was under these circumstances that an effort was made in Aberdeenshire to deal with the question. The work was taken up successfully and carried on continuously for seven years, by the Aberdeenshire Agricultural Association, which in 1882 was developed by the addition of a farm, laboratory, museum, &c., under the name of the Agricultural Research Association for the North-Eastern Counties of Scotland.

At the request of the Editor of this edition of *The Book of the Farm*, Professor Thomas Jamieson, F.I.C., chemist to the Association, who has all along had the active management of the experiments, has kindly furnished the following account of the progress and results of these historical experiments.

The experiments were commenced in 1875. They had been framed with great care, scrutinised and amended by several gentlemen familiar with the various aspects of the question, chiefly by Mr J. W. Barclay, M.P., who was familiar with the manure trade and with farming, and had given close attention to the scientific aspect of the question; by Mr John Milne, Mains of Laithers, farmer, manure manufacturer, and holder of the Highland Society's diploma; by Mr Ranald Macdonald, factor on the Cluny estates; and by the chemist to the Association. The scheme of experiments, provisionally made, was thus scanned from all aspects, and was then laid before the committee (presided over by the Marquis of Huntly), fully discussed, and finally adjusted. It will thus be seen that its scientific accuracy and direct practical bearing were well assured.

The Experimental Stations.—Five different sites were fixed upon, at altitudes varying from 1 to 400 feet above sea-level; at distances from the sea varying from 2 to 30 miles; and representing soils of different characters and different degrees of fertility; the depth of mould varying from 8 to 36 inches; while the subsoils represented crumbling granite, gravel, and sand, yellow clay, bluish clay, and stiff red clay.

Size of Plot.—Each site was about two acres in size, and was enclosed by a substantial fence. This area gave space for a large number of plots, of the size that had been so highly recommended by the late Professor Anderson, chemist to the Highland and Agricultural Society—viz., $\frac{1}{112}$th part of an acre.

It may be mentioned in passing, that Professor Anderson arrived at this size after much experience with experiments on a larger scale. It may also be mentioned that the same experience was got in Aberdeenshire; preliminary experiments on $\frac{1}{10}$th and on $\frac{1}{20}$th acre plots having been made, while along with the large number of $\frac{1}{112}$th acre plots, a large field was divided into $\frac{1}{4}$th acre plots. This experience gradually led to a clearer discernment of the objectionable features of large plots, and to a distrust in their results; while Professor Anderson's opinion was abundantly confirmed, that the $\frac{1}{112}$th acre plot is a most suitable size for field experiments, while it is also very convenient for calculation, as every pound of manure applied, or of crop reaped, represents the same number of cwts. per acre.

Discussion as to Size of Plot.—It is only what is to be expected that this subject of size of plot will crop up every now and again; familiarity with work on large areas engendering a leaning towards large experimental plots, while greater familiarity with actual experimenting leads to the small plot, as ensuring uniformity of soil, as well as identical cultivation under the same climatic conditions, and hence fair comparison. The $\frac{1}{112}$th acre plot is indeed too large; but it is probably as small as can be adopted, unless the soil is actually taken up, and thoroughly mixed, and returned in equal quantities to the former position. Under such arrangement the $\frac{1}{1000}$th acre plot will be found in the highest degree satisfactory.

It is interesting to notice how steadily opinion grows in favour of small plots, and how constantly the above experience is repeated—namely, that every beginner, especially if associated or influenced, directly or indirectly, with practice on the large scale, begins with large plots, and gradually works towards the smaller ones.

Duplicated Plots.—Especial care was taken to have each experiment duplicated, a feature too often neglected in experiments. It is indeed desirable that they should even be triplicated.

In the experiments having reference specially to phosphate applied with and without nitrogen, special care was taken that there should be no hindrance to the action of these essentials by the absence of other materials understood to be essential. This was prevented by the application, all over the plots, of a mixture consisting of 3 cwt. potassic chloride, 1 cwt. magnesia sulphate, and ½ cwt. common salt. Each plot was surrounded by a deal-board nine inches deep, driven edgewise into the soil.

Adjusting the Manures.—The soils were subjected both to chemical and mechanical analyses. The manures were also analysed, and care taken that equal quantities of the ingredients were used. In the earlier experiments, however, the proportion of insoluble phosphate was a half more than soluble phosphate, an adjustment considered necessary in order that the two phosphates might be fairly compared, assuming that the finer division or greater distribution of the soluble phosphate would give it undue advantage in a fair trial of the relative powers of the two substances. Possibly this adjustment was unnecessary; the probable effect was to provide a larger quantity of phosphorus in the case of the insoluble form than was necessary. In the later experiments, therefore, equal quantities were adopted, with about the same result as had previously been got in the crop. In the first instance, also, the soluble phosphates were exactly a half soluble (*i.e.*, in commercial terms about 20 to 26 per cent superphosphate). In the later experiments, however, the highest practicable degree of solubility was sought—viz., about 35 per cent soluble.

On singling the plants (turnips) it was sought to have an equal number in each plot—namely, about 200; but that number, from various causes, which will be easily understood by those engaged in practice, was seldom maintained to the end of the season. Attacks by insects, weakly plants, frost, drought, &c., frequently reduced the number.

None of the operations on the plots were allowed to go on, nor weighing of the crop, except in the presence of the chemist who directed the experiments.

It may thus be seen that the most scrupulous care and attention were given to the whole work.

First Year's Conclusions.

At the end of the year the numerous and duplicated results of this large series of experiments were tabulated, and presented such a varied and confirmed series of results as probably had not previously been available. They were carefully considered by the individuals above mentioned, and others taking part in the direction, and finally the following conclusions were adopted:—

1. That *phosphates of lime* decidedly increase the turnip crop, but that farmers need not trouble themselves to know whether the phosphates are of animal or of mineral origin.

2. That soluble phosphate is not superior to insoluble phosphate to the extent that is generally supposed.

3. That nitrogenous manures have little effect on turnips used alone, but when used along with *insoluble* phos-

phates increase the crop; that the addition of nitrogen to *soluble* phosphates does not seem to increase the solids or dry matter in crop; that there is no material difference between the effects of equal quantities of *nitrogen* in nitrate of soda and in sulphate of ammonia.

Note.—Pure sulphate of ammonia contains about 5 or 6 per cent more nitrogen than nitrate of soda.

4. That fineness of division seems nearly as effective in assisting the braird and increasing the crop as the addition of nitrogenous manures. Hence the most economical phosphatic manure for turnips is probably insoluble phosphate of lime, from any source, ground down to an impalpable powder.

Condensed Results.—It would occupy too much space to give the results in detail. It may suffice to give a few condensed results—namely, a few results from the station that responded best to the action of phosphate, and therefore showed the relative action of the different forms most clearly; and also the results of the five stations averaged:—

		Aboyne. Turnips. Tons per acre.	Average of 5 Stations. Turnips. Tons per acre.
Group I.	No phosphate given	5	10
	Insoluble phosphate (ground coprolite)	19	16
	Soluble phosphate (superphosphate)	22	18
Group II.	Insoluble phosphate and nitrate of soda	21	18
	Soluble phosphate and nitrate of soda	26	21
Group III.	Insoluble phosphate and sulphate of ammonia	23	20
	Soluble phosphate and sulphate of ammonia	24	20
Group IV.	Raw bone-meal	16	16
	Steamed bone-powder	23	20

Insoluble Phosphates as Plant-food.—From the point of view of new information, the first and last groups are by far the most important. Formerly coprolite was deemed of no manurial value until rendered soluble by sulphuric acid; and in placing a money value on a dissolved manure, no value was attached to the insoluble portion it contained. The above results indicated that this position was untenable. They led the Aberdeenshire Association to say decisively that insoluble phosphate in the form of ground coprolite was directly effective on plants, and to add the statement that the superiority of the soluble form is not so great as is generally supposed. It was thought well to limit expression to the latter general and tentative statement, reserving a definite statement till further results were obtained.

The fourth group indicates the excellent results got by using phosphate in a fine state of division, and led to the fourth conclusion stated above.

It may be remarked that these opinions are now generally accepted. No doubt there may constantly be heard dissentients from these doctrines. That is only what may be expected, when the subject concerns so large a body as the whole agriculturists of a kingdom. But no responsible person will now be found to take up an opposite position.

The bearing of the New Doctrine.—At this stage there ought to be prominently brought forward the real bearing of this new doctrine on agricultural practice.

What is the actual effect of the knowledge that the natural coprolite, merely ground, is able directly to feed the plant with phosphate? Being decidedly the cheapest form of phosphate, does it follow that it should be employed to the exclusion of all other phosphates? Assuredly not, when it is so clearly brought out that although it produces 16 tons per acre, other forms produce 18 tons, and others 20 tons per acre. Assuredly not again, when it is stated that greater assistance is given to the plant in the early stage, by more finely divided phosphate, or by soluble phosphate. So long as the latter two phosphates are not charged a higher price, as compared with coprolite, than is compensated by the larger crop, they should be used. So soon, however, as the price advances much beyond that point, the agriculturist

can fall back on coprolite, which is found abundantly in many parts of the world, and requires no more manufacture than simple grinding.

It is thus wholly and solely a matter of price. And herein lies the important practical bearing of the new doctrine. It is well to grasp fully the significance of the knowledge that coprolite may be used directly. Put in few words it is this—*that it provides a check to the undue raising of the price of manufactured phosphates.*

Experiments of Subsequent Years.

It would go beyond the limits of this article to explain the many points that engaged the Aberdeenshire Association during the following six years—viz., till 1882—during which the experiments of the first year were continued and repeated, providing altogether many hundreds of results. The proceedings of the Association, for that period of seven years, form a large volume, replete with tables, diagrams, and photographs, which provide the critic with full details, while at the same time the main points are clearly brought out for the general reader. It may suffice to say that the following points were very fully entered into:—

1. The *specific gravity of turnips*, which was found to give no reliable indication of their quality.

2. The *proportion of water in turnips*, which was found to be increased both by nitrogenous, and, to some extent, by soluble phosphatic manures.

3. "*Finger and toe*" *disease* was investigated; farmers' opinions regarding it widely ascertained; many experiments conducted to ascertain the effect of manures in giving rise to the disease; and other experiments with the view of finding a remedy. Speaking generally, it was found that whatever weakened the plant predisposed it to disease, and rendered it an easy prey to its natural fungoid enemy, which then produced the disease. But while many influences, both mechanical and climatic, caused weakness, it was found, in a very remarkable and unmistakable manner, that soluble phosphate produced this effect in a very striking degree. Nor was this effect confined to phosphate rendered soluble by sulphuric acid, but sulphur in various forms seemed more or less to have a similar effect. As to a remedy, the disease seemed lessened by whatever ensured healthy growth, or a condition of soil uncongenial to fungoid growth, as well as such lapse of time between the two turnip crops as would reduce the natural food of the fungus, while a heavy dose of lime markedly lessened the proportion of disease.

4. The *variation in weight on oat grain by storing;* the solid nourishing matter in oats differently manured; and the proportion of husk to kernel.

5. *Different methods of storing turnips* during winter were tried, and the method of storing in pits of two or three loads, and covered with three or four inches of earth, was found to answer best; while the result was not greatly different whether or not the roots or leaves, or both, were cut off previous to storing.

The first series of experiments was, as mentioned, on turnips, and turnips were grown on the same ground successively for five years.

But in the second year of the experiments, the original experiments were repeated on new ground at each station, and the effect of the various manures ascertained over a rotation.

Relative Value of Phosphates and Nitrogen.

At the end of seven years it was considered that the subject that had been carefully avoided up to that time might then be approached—viz., to fix the relative agricultural value of phosphates and nitrogen. This was done, not by attaching a money value, which might vary every year, but by fixing on some large natural source of phosphate, and a similar source of nitrogen, and adopting these each as a standard, to be referred to by the figure 10. The standard adopted for phosphate was ground coprolite of the usual commercial degree of fineness, which was called 10; while the standard chosen for nitrogen was nitrate of soda, the value of which was also called 10.

It may be necessary later on to make these standards more definite, by specifying more distinctly the precise state of mechanical division; and obviously the finer the division chosen for the standard, the less will be the difference be-

tween it and the forms standing above it. But for the immediate purpose the commercial forms were deemed sufficient.

The values thus carefully arrived at for phosphate were :—

Phosphate of iron	0
Phosphate of alumina (redonda)	3
Tribasic phosphate of lime in bone	10
Tribasic phosphate of lime in insoluble mineral	10
Monobasic phosphate of lime in soluble phosphate	12
Bibasic or tribasic phosphate of lime in precipitated form	13
Tribasic phosphate of lime in steamed bone flour	14

While the values for nitrogen were as follows :—

Nitrate of soda	10
Sulphate of ammonia	10
Guano	10
Nitrogen (only) in bones (supplemented with dried blood)	8

At the same time the conclusions originally framed were more specifically drawn out as follows :—

Final Conclusions.

1. Non-crystalline phosphate of lime, ground to a floury state, applied to soil deficient in phosphate, greatly increases the turnip crop, and also, though to a less extent, the cereal and grass crops, but always with equal effect, whether it be derived from animal or mineral matter.

2. Soluble phosphate is not superior in effect to insoluble phosphate if the latter be in finely disaggregated form—*e.g.*, disaggregation effected by precipitation from solution, or by grinding bones after being steamed at high pressure. In such finely divided conditions, the difference is in favour of the insoluble form, in the proportion of about 12 for the soluble to 13 and 14 for the above insoluble forms respectively. In less finely divided form (such as mineral phosphate impalpable powder), insoluble phosphate is inferior to soluble phosphate in the relation of about 10 to 12.

3. Nitrogenous manures used alone have little effect on root crops, unless the soil is exceptionally poor in nitrogen, and rich in available phosphate.

Nitrogenous manures used with phosphate on soils in fairly good condition give a visible increase of root crop, but this increase is due mostly, and often entirely, to excess of water in the bulbs.

Nitrogenous manures greatly increase cereal crops, and the increase in this case is not due to excess of water.

As to the relative efficacy of different forms of nitrogen: the ultimate effect of nitrogen in sulphate of ammonia, in guano, and steamed bone flour, is nearly identical, whether used with soluble or insoluble phosphate. Nitrate of soda, when used with soluble phosphate, is also identical with the above forms, but is of less efficacy when used with insoluble phosphate.

4. Fine division (or perfect disaggregation) of phosphates assists the braird nearly as much, and with more healthy results, than applications of nitrogenous manures.

The most economical phosphatic manure is probably non-crystalline, floury, insoluble phosphate of lime; the cheapest form being mixed with an equal quantity of the form in which the highest degree of disaggregation is reached.

(At present these two forms are respectively, ground mineral phosphate (coprolite), and steamed bone flour.)

Duplicate Trials in England.

It remains only to say, that it having been argued that while these results might apply to soil in Scotland, poor in lime, and not to soils in England, generally richer in lime, it was considered desirable to ascertain whether or not the results had only this limited application.

A station was therefore established in Huntingdon, and another in Kent, while later on a large number of experiments were established in Sussex, and carried on by the Sussex Association for the Improvement of Agriculture, under the same chemical direction as the Aberdeenshire experiments. These experiments in England showed, that while in soil actually on the chalk formation soluble phosphate showed to more advantage than on all the other soils tried, yet in the other soils in Sussex and in Huntingdon, where the soil was not so purely chalky, but yet contained the ordinary quantities of lime, the results were practically the same as those got in Aberdeenshire.

Outside Confirmation.

The value of these experiments in Aberdeenshire and Sussex would be uncertain unless confirmed not only in other places, but by other and independent experimenters. The importance of the question, however, was widely recognised; and after some time, both the Highland and Agricultural Society of Scotland, and the Royal Agricultural Society of England, established experiments on the same subject, as did also a number of private experimenters, all of whose results pointed more or less conclusively in the same direction.

Still the march has been slow, if we judge its progress by the amount of coprolite applied, or by the small effect on the superphosphate trade. But for this there are two obvious explanations; first, as already explained, that the effect is not to be looked for in the direction of the greater use of coprolite, but rather in the reduction of the prices of superphosphate and other phosphates—and this reduction has indeed taken place to a very marked extent; and, second, that the interest of the trade is more than able to cope with the agriculturist, who at the present day is hardly so skilled in the intricacies of manure as in a few years he is likely to become.

Scope of the Sussex Experiments.

Allusion has been made to the experiments conducted in Sussex under the name of the Sussex Association for the Improvement of Agriculture. As these experiments have been going on for eight years, in eight different sites throughout the county, representing the chalk formation, the weald clay, Hastings-beds and greensand, it will be evident that the amount of work and number of results thus ascertained are too extensive to admit of satisfactory treatment here. It may be mentioned however, that, beginning with experiments testing not only phosphorus but also nitrogen and potassium in different forms, on which a great amount of both interesting and useful information has been obtained, attention has been directed latterly to the means of improving old pasture, and to the laying down of new pasture in such a way as to ascertain the effect of different seeding, different manuring, liming, draining, &c.

HIGHLAND AND AGRICULTURAL SOCIETY'S EXPERIMENTS.

In the year 1878, a series of field experiments was inaugurated by the Highland and Agricultural Society of Scotland. For the following account of these experiments we are indebted to Dr A. P. Aitken, chemist to the Society, under whose care they were conducted:—

Object of the Experiments.—The object of these experiments was to test the accuracy of many views then prevalent regarding the efficacy of the various light manures in use among farmers, to discover what was the agricultural or crop-producing values of these substances, and to see how far these values corresponded with the prices at which the substances were being sold in the market.

It was believed by many advanced farmers that large sums of money were annually being spent in the purchase of manurial substances, whose efficacy as manures was entirely out of harmony with their market prices, and that nothing short of an extended series of experiments, performed upon an agricultural scale over two rotations, would be capable of uprooting old prejudices, and of enlightening farmers regarding the true value of the substances in which so much of their capital was being invested. It was believed that such a series of experiments would not only determine, in a practical and reliable manner, what was the real value of manures, but would also supply much-needed information regarding the special utility of the various ingredients of manures, the forms in which they could be most profitably employed, and the most rational and economical methods in which to apply them.

The Stations.—For this purpose the Society rented two fields—one at Harelaw, in East Lothian, and one at Pumpherston, in West Lothian. At each station 10 acres were set apart and divided into forty plots of one rood each. The soil of the former, a rich deep loam near the sea-level, in a dry early district; and that of the latter a thin clayey loam, resting on the till or boulder clay, a

somewhat wet and late district, 400 feet above the level of the sea.

No dung was applied to the stations during the course of the experiments, nor for four years previous to their commencement.

Manures tried.—The three classes of manures under experiment were phosphates, nitrogenous matters, and potash salts of the following kinds:—

Phosphatic Manures.

- Mineral phosphates
  - Carolina land phosphate.
  - Canadian apatite.
  - Curaçoa phosphate.
  - Aruba phosphate, &c.
- Of remote animal origin
  - Phosphatic guano.
  - Coprolites.
- Of recent animal origin
  - Bones, in various forms.
  - Bone-ash.

These were applied in a finely ground state, and also after having been dissolved in sulphuric acid.

Nitrogenous Manures.

- Soluble
  - Nitrate of soda.
  - Sulphate of ammonia.
- Insoluble
  - Meat-meal
  - Dried blood
  - Horn-dust
  - Keronikon
  - Shoddy or wool-waste
  - (of animal origin.)
  - Rape-cake dust
  - Cotton-cake dust
  - (of vegetable origin.)
- Guanos, &c.
  - Peruvian guano.
  - Ichaboe guano.
  - Fish-manure.
  - Frey Bentos manure.

Potash Manures.

- Sulphate of potash.
- Muriate of potash.

These manures were so applied that each plot received the same quantity of *phosphoric acid, of nitrogen, and of potash*, whatever might be the form in which these were applied, and irrespective of the gross weights of the substances, or of their market prices.

Cropping.—The cropping consisted of a four-course rotation of turnips, barley, beans, and oats.

Manures for Turnips and Beans.—When the crop was turnips or beans, the manures applied to these plots contained—

	lb. per acre.
Phosphoric acid	160
Nitrogen	40
Potash	120

Manures for Cereals.—When the crop was barley or oats, the manure contained—

	lb. per acre.
Phosphoric acid	80
Nitrogen	40
Potash	60

The plots on which the various *phosphatic manures* were tested, received, in addition, their proper quantity of potash in the form of a mixture of muriate and sulphate, and their nitrogen in the form of nitrate of soda.

The plots on which the various *nitrogenous manures* were tested, received, in addition, their proper quantity of phosphoric acid in the form of superphosphate, and their potash as mixed sulphate and muriate.

The plots on which the two *potash salts* were tested, received their proper quantity of phosphoric acid as superphosphate, and their nitrogen as nitrate of soda.

The great majority of the plots on the stations were thus fully manured; and in so far as the essential ingredients—phosphoric acid, ammonia, and potash—were concerned, they all fared alike. It was only the outward and accidental form and fashion of these substances that differed.

In order to form a starting-point or basis of comparison for the whole station, three plots received no manure whatever.

In order to measure the specific effects of each of the three essential ingredients, three plots received one of each and nothing else, while from other three plots each of the three essential ingredients respectively was withheld.

In addition to the two series of experiments on the stations, there were annually carried out a selected number of experiments on farms in various parts of the country to test the accuracy of the results obtained, and to acquire additional information regarding the action of manures when applied to different soils and under different climatic conditions.

Full reports of the experiments were published annually in the Society's *Transactions*, and the following is a general statement of the chief results obtained and observations made.

I. Results with Phosphatic Manures.

Produce of Dry Matter from Pumpherston.—During the eight years comprised in the two rotations, the total amount of dry vegetable matter per acre, in the form of roots, grain, and straw, removed from the plots to which *complete manures* had been regularly applied on that section of the station at Pumpherston devoted to the study of phosphatic manures was as follows:—

	Tons of Dry Matter, per acre.	
	Undissolved.	Dissolved.
Bone-ash . .	12.69	12.66
Ground coprolites	11.80	13.22
Bone-meal . .	11.32	13.80
Phosphatic guano	12.47	14.11
Ground mineral phosphates . .	11.66	14.16
Average	11.99	13.59

Conclusions. — The facts apparent from a mere glance at these figures are, that—

Soluble phosphates have produced about 13 per cent more actual fodder than insoluble phosphates.

Bone-meal, which is one of the dearest of the phosphates, has given the smallest return.

Dissolved mineral phosphate, which is just ordinary superphosphate, and made from the cheapest material, has given the largest return.

Among the insoluble phosphates, *phosphatic guano* and *bone-ash* are best.

Over a series of eight years, the amount of fodder raised by the application of different kinds of insoluble phosphates are not very different.

The following facts, although not apparent from a mere scrutiny of these figures, were attested from year to year during the course of the experiments:—

Insoluble Phosphates.—These vary in their efficacy far more than soluble phosphates. They are more dependent on moisture for their activity, and during dry seasons they are of very little use. Even during wet seasons they were found to be very capricious in their action. The phosphate which was the best one year might be the worst the next year.

Fineness of Grinding.—This uncertainty was found to be caused by the different *degrees of fineness* to which they happened to be ground. The finer they were ground, the more effective they were as manures.

A series of experiments made in 1886, on four plots of Pumpherston and on four Lowland farms, with the same mineral phosphate, in two slightly different degrees of fineness, showed uniformly a difference of about 11 per cent in favour of the more finely ground phosphate. The whole question of the efficacy of ground phosphates has been shown to turn on the point of the fineness to which they are ground.

Phosphatic Guano.—The reason why phosphatic guano is so effective a form of insoluble phosphate is presumably because it consists in great measure of very finely divided matter, and also because it contains from 5 to 10 per cent of precipitated or "reverted" phosphate which is in an infinitely fine state of division.

Bone-meal.—The reason why bone-meal is slowest in its action, is probably because it consists in large measure of very coarse particles.

Judged by the standard of fineness of division alone, bone-meal, which was enormously coarser than the other phosphates, should not have produced nearly so much vegetable matter. Its efficacy must therefore depend on other circumstances—notably its power of rotting in the soil, and of accumulating a store of phosphate, in no very long time becoming available as plant-food.

Soluble Phosphates.—Although the eight years' record shows that the soluble phosphates differ more widely in their efficacy than the insoluble ones, they have not varied up and down so much as the latter. Their action was much more steady and reliable. Nevertheless their relative order of activity did alter on some occasions.

Just as the undissolved phosphates differed from year to year in their fineness of grinding, so the dissolved phosphates differed from year to year in the fineness of their manufacture, or in their state of aggregation due to dampness, or the time during which they were kept in bags before being applied. Dissolved manures are liable to cohere into lumps from various causes, and the most careful

riddling cannot restore the fine condition of a manure that has become lumpy.

Fine Powdery Condition essential.—Attention was early drawn to this circumstance during the course of the experiments, and observations made showed clearly that the efficacy of dissolved manures depends very much upon the more or less *powdery condition* in which they are applied. It is to this circumstance, more than to any other, that the variation in the amount of the produce from the application of different forms of soluble phosphate must be attributed, and from the results of these experiments the following affirmation may be made:—

Given two phosphates of somewhat similar composition, but of different degrees of fineness, the superiority will lie with the finer one, whatever be its origin or history, or by whatever name it may be called.

More Vigorous Growth from Soluble Phosphates.—On the plots to which soluble phosphates were applied the plants brairded sooner, the turnips came sooner to the hoe, and met sooner in the drills, and the cereals were ripe and ready for harvesting from a week to a fortnight earlier than on those plots manured with insoluble phosphates. These important advantages were especially noticeable during dry seasons.

Owing to the more vigorous growth on the plots manured with soluble phosphates, their crops were *less liable to disease*, and the land was always cleaner than on the other plots.

Harelaw Results.—The results obtained at the Harelaw station were very similar to those obtained at Pumpherston, but owing to the high state of fertility of the soil the differences were not so well marked.

Insoluble Phosphates for Mossy Land, &c.—A large number of experiments to determine the relative utility of soluble and insoluble phosphates were made on farms differing widely in their soil and climate, and it was found that insoluble phosphates produced their best results upon mossy land, and soils rich in organic matter in wet districts. In such circumstances they were a more economical manure than superphosphate.

Bones and Fineness of Grinding.—An extended series of experiments carried out on the stations, and on other farms, to test the relative manurial value of bone-meal of different degrees of fineness, showed that the finer ground bone-meals gave the best results during the season in which they were applied, and also during succeeding seasons where their after-effects were observed.

II. Nitrogenous Manures.

Produce of Dry Matter at Pumpherston.—The following are the amounts of dry vegetable matter removed from the plots at Pumpherston that were set apart to determine the relative efficacy of nitrogenous manures during the two rotations. The manures contained in each case the same amount of nitrogen, and there was given along with it a definite uniform amount of superphosphate and potash salts.

	Tons per acre.
Nitrate of soda . . .	12.22
Sulphate of ammonia . .	11.62
Horn-dust, shoddy, &c. .	9.28
Dried blood . . .	10.38
Rape-cake dust . . .	10.96

As in the case of phosphates, so also in the case of nitrogenous manures, the most soluble substances produced the largest return.

Nitrate of Soda.—This is the most active and efficient of all the nitrogenous manures, and its action has been studied under a variety of conditions at the stations, and on other soils of very different character.

Its chief peculiarity is that it acts almost immediately on the crop, and produces a marked effect whether ploughed in with the seed or applied as a top-dressing during the growth of the crop.

When applied to land in good condition, or when it forms part of a complete manure, it causes the crop to braird vigorously, and is sometimes the saving of a crop whose youth is precarious. It is especially valuable in seasons of drought, as it enables the young plant to root rapidly and become less dependent on surface-moisture.

When applied to cereals it causes a more abundant growth of straw than any other manure. When applied with the seed or to the young braird, it not only increases the bulk of the crop, but

it hastens its development and causes it to ripen sooner. If applied at a later period, it causes the plant to grow too much to stem and leaf, and it unduly prolongs the period of growth. When applied late as a top-dressing to cereals, it causes a disproportionate growth of straw, retards the period of ripening, and favours the production of light grain.

When applied to a thin sharp soil during a wet season its effect is transient, showing that much of it has been washed down through the soil and out of reach of the roots of the crop.

When applied too liberally on good land, it causes a rapid growth of ill-matured vegetable matter, and produces a crop which is too abundant, unable to ripen, of poor feeding value, and liable to accidents.

When applied to plants grown for their seed, nitrate of soda must be used more sparingly; for increase of stem or straw, if overdone, is secured at the expense of the seed, both in quantity and quality.

It may therefore be used with greater impunity to crops which are grown for the sake of their stem and leaf—chiefly and notably to grass of one or two years' duration.

When applied liberally to grass, it increases the growth of the grasses proper, but diminishes the amount of clover and other leguminous plants; therefore, when a good crop of clover is desired, nitrate should be used very sparingly.

Sulphate of Ammonia.—Sulphate of ammonia is slower in its action than nitrate of soda. It is therefore to be preferred as a nitrogenous manure for crops which have a prolonged period of growth. When applied as a top-dressing to cereals, it retards the time of ripening. A similar effect is produced when applied with the seed in dry districts or during seasons of drought. It does not fail to benefit the crop even upon thin soils and during wet seasons. It is therefore more appropriate than nitrate of soda for application in these circumstances.

Sulphate of ammonia can do little for the germinating seed in dry weather, as it is not in an immediately available form. Even after rain comes, it is some time before the sulphate of ammonia comes into action.

Sulphate of ammonia has been found to check the growth of clover more effectively than nitrate of soda if applied in excess, but in moderate quantity it is an excellent manure for old grass. It is not suitable for application to leguminous crops, which are intolerant of strong nitrogenous manures, especially after the first period of their growth.

Insoluble Nitrogenous Manures.

Insoluble nitrogenous manures are substances containing albuminoid matter. They are very suitable for wet districts, but none of them can be considered a manure until it is finely ground, or rotted, or dissolved.

Rape-cake Dust.—Among the insoluble nitrogenous manures rape-cake dust has produced the greatest amount of vegetable matter. It is very probable that this is due in some measure to the large amount of carbonaceous organic matter contained in it. It was also noticed that the plot to which this manure was applied was singularly free from disease, and that the texture of the soil improved under its application.

Dried Blood, Horn-dust, &c.—Dried blood was found to be a good manure for roots, especially when applied early, but too slow in its action for cereals.

The same remark applies to *horn-dust* and *keronikon*, which should be applied long before sowing. *Shoddy* was tried on only one occasion, and was found quite inoperative.

All these insoluble nitrogenous matters become, when dissolved in sulphuric acid, good quickly acting manures.

III. Potash Manures.

Potash salts are chiefly important on land that has not been dunged. On dunged land they frequently fail to produce any marked effect.

Sulphate and *muriate* of potash are nearly equal in their action. They are most effective when applied some months before sowing. The crops to which they are most beneficially applied are beans, clover, and leguminous crops generally.

When applied to cereals, they increase the amount of grain to some extent, and they make the straw more elastic and less liable to lodge.

Manuring Turnips.

The manurial constituents of greatest importance in raising a crop of turnips are phosphoric acid and nitrogen.

The relative importance to the turnip crop at Pumpherston of these two ingredients of potash, is seen by comparing plots manured as under during four years:—

No. of Plot.	Roots per acre. tons.	cwt.
22. Potash	6	14
12. Phosphate (bone ash) .	9	2
18. Nitrate . . .	13	8
11. Potash and nitrate .	8	2
21. Phosphate and nitrate .	14	10
1. Phosphate, nitrate, and potash . . .	16	4

Effects of Manures on Turnips.—The chief effect of manuring on turnips is to increase the quantity per acre, but the quality of the turnip is also much affected by the nature of the manure.

Turnips manured with dissolved phosphate contain a higher percentage of ash than those manured with ground phosphates.

They also contain a somewhat smaller proportion of albumen, and upon the whole they have a wider ratio of albumen to carbohydrates, which means that they have not quite so high a feeding value.

The diminished percentage of albumen produced by the use of dissolved phosphate was counterbalanced by the increase in the total crop, so that the total amount of albumen per acre was somewhat in favour of the crop grown with soluble phosphate.

Dissolved phosphates when applied in April produced a better crop of turnips than when applied with the seed in June. The earlier manured turnips were denser, and produced more solid food per acre than the others.

Turnips manured early had more ash than those manured with the seed.

When the nitrogenous manure of turnips is given entirely in the form of nitrate of soda or of sulphate of ammonia, the latter has been found to produce a denser, sounder turnip.

The best way of applying potash to turnips is to apply it several months before sowing.

Potash manures cause an increase in the amount of turnip-tops, but retard the ripening of the bulbs.

An excess of potash manures decreases very materially the quantity of roots, and may greatly injure the crop.

It is scarcely possible to overdo the application of phosphates to turnips, so far as the health and feeding quality of the roots are concerned; but too liberal an application of nitrogenous manure unduly increases the tops and retards the ripening of the bulbs, and also increases their liability to disease.

General Observations on Turnips.

Turnips contain a smaller percentage of solids than swedes. The turnips at the stations contained from 7 to 9 per cent solids, and the swedes from 10 to 12 per cent.

The solid matter of the swedes contained 15 per cent more albuminoids than that of the turnip, and there was as much nourishment in 10 tons of swedes as in 13 tons of turnips.

Turnips contained in their dry matter nearly 8 per cent of ash, and swedes only about 5½ per cent. The latter were therefore less exhausting to the land.

Large turnips are not so economical as medium-sized ones in any way. They contain more water, and produce less solid matter per acre. The larger they are, the smaller is the proportion of true albumen in their solid matter; they are the less mature, and the less nutritious. They contain a higher percentage of ash, and are therefore more exhausting to the soil. They have a low specific gravity, and are usually spongy in the heart. They are more liable to rot, and do not keep so well when pitted. Turnips at their best are too watery a diet, but the larger they are the poorer the diet.

Small turnips, on the other hand, are not so profitable as *medium turnips*, because they do not produce so much solid food per acre, and although they contain a higher percentage of solids and a smaller percentage of ash, yet their solid matter consists largely of indigestible woody fibre, and is therefore less nutritious.

The nitrogenous matter in turnips is partly of a nutritive and partly of a non-nutritive kind. The former consists of albuminoid matter. The ratio of nutritive to non-nutritive nitrogenous matter

varies extraordinarily in different turnips, and under different circumstances of weather and manuring.

Forced Turnips of Bad Quality.—Bulbs grown very rapidly, whether from excess of moisture or too liberal application of soluble nitrogenous manure, have a smaller proportion of their nitrogenous matter in the form of albumen.

Manures which unduly force the growth of turnips may increase the quantity of the crop; but the increase of quantity is got at the expense of quality, and the deterioration of quality is mainly expressed in the large percentage of water and the small percentage of albumen in the bulbs.

Manures for Rich Crops of Turnips.—In order to grow a large and at the same time a healthy and nutritious crop of turnips, such a system of manuring or treatment of the soil, by feeding or otherwise, should be practised as will result in the general enriching and raising of the condition of the land, so that the crop may grow naturally and gradually to maturity.

For that purpose a larger application of slowly acting manures, of which bone-meal may be taken as the type, is much better suited than smaller applications of the more quickly acting kind.

A certain amount of quickly acting manure is very beneficial to the crop, especially in its youth; but the great bulk of the nourishment which the crop requires should be of the slowly rotting or dissolving kind, as uniformly distributed through the soil as possible.

Manures for the Barley Crop.

The relative importance to the barley crop of the three manurial ingredients may be seen from a comparison of the results obtained on the plots manured as under for five years:—

No. of Plot.	Grain per acre. lb.
22. Potash	875
12. Phosphate (bone-ash)	1175
17. Phosphate and potash	1256
18. Nitrate	1287
21. Nitrate and phosphate	1706
11. Nitrate and potash	1814
13. Nitrate, potash, and phosphate	2596

Manures applied to the barley crop affect, in the first place, the quantity per acre both in grain and straw; in the second place, and to a much less extent, they affect the quality of both grain and straw, and they materially affect the time of ripening.

Nitrogenous Manure for Barley.—The most important constituent of a manure for the barley crop is nitrogen. In ordinary circumstances, it is the quantity of nitrogen in the manure or in the soil which determines the bulk of the crop.

In an ordinary rotation of cropping, in which barley succeeds turnips, the *phosphate and potash* required by the crop are relatively abundant in the soil, and a good crop can be obtained if only some nitrogenous manure is applied in sufficient quantity to enable the plant to take up its mineral food.

The kinds of nitrogenous manure most suitable for barley are those which are soluble and rapid in their action, such as sulphate of ammonia and nitrate of soda. *Sulphate of ammonia*, if applied as a top-dressing, and *nitrate of soda*, if so applied, much later than three weeks after the date of sowing, may increase the quantity of the crop both in grain and straw, but the quality of the grain, as indicated by the weight per bushel, will be lowered, and the time of ripening will be retarded.

A difference of three weeks in the time of ripening occurred among the experimental crops. The earliest were those which were manured with soluble phosphate, and whose nitrogenous manure was nitrate of soda applied with the seed. The latest were those which received no nitrogenous manure, an overdose of it, or too late a top-dressing.

Slowly acting nitrogenous manures are of no use to the barley crop, unless applied some months before the time of sowing.

A deficiency in the amount of nitrogenous manure applied to barley not only diminished the total amount of the crop, but it also diminished the percentage of albuminoid matter contained in the grain.

Barley, top-dressed with nitrate of soda, contained somewhat more albuminoid matter than that which had the nitrate applied with the seed.

The amount of albuminoid matter varied from 8½ to 11½ per cent. The

former amount was contained in barley, from whose manure all nitrogenous matter was withheld, and the latter from barley top-dressed with nitrate.

Phosphatic Manures for Barley.—*Phosphatic manures* are next in order of importance for barley. The more speedy their action the better; therefore *superphosphate* is the most reliable form of phosphate.

The plots to which soluble phosphates were applied came to maturity ten days before those with insoluble phosphates.

Potash for Barley.—Potash manures somewhat increased the quantity of grain on the station where no dung was applied, and they strengthened the straw. But it was noticed that the grain was somewhat darker in colour than that to which no potash was appplied.

Manures for Oats.

The manures required for oats are quick-acting manures, to enable the crop to get a good hold of the soil before the nourishment contained in the seed is exhausted.

For this purpose superphosphate and nitrate of soda are peculiarly applicable.

Sulphate of ammonia, although a soluble manure, did not come into operation in time for the wants of the young plant during the dry season of 1885, and the crop which received that manure was a signal failure at both stations.

Potash manures, especially muriate of potash, had a very beneficial effect upon the oat crop, and considerably increased the yield of grain, and in a less degree the amount of straw.

The *general conclusions* to be drawn from the experiments with the oat crop are, that the treatment of the land should be such as to accumulate organic matter in it, to prevent too great a loss of moisture, and to provide the young plant with manures that come rapidly into operation.

When the young plant has safely passed the critical period of its growth it roots deeply, and lays hold of the moisture and nourishment contained in the subsoil.

Manures for the Bean Crop.

The usual practice in bean-growing districts is to apply dung to the bean break, and the opinion prevails that beans cannot be successfully grown without dung. But the experiments at Pumpherston station show that a full crop of beans may be grown with artificial manures upon land that has not been dunged for ten years.

The relative importance to the bean crop of the three chief constituents of a manure may be seen by comparing the produce of eight plots manured as follows for six years:—

No. of Plot.	Kind of Manure.	Bushels Dressed Grain per acre.
27.	No manure . . .	2½
12.	Phosphate (bone-ash) .	5⅙
18.	Nitrate . . .	6¼
21.	Phosphate and nitrate	5⅓
22.	Potash . . .	26½
17.	Potash and phosphate .	42½
10.	Potash, phosphate, and nitrate	45½
38.	Potash, phosphate, nitrate, and gypsum . . .	51

The characteristic ingredient of a bean manure is potash.

Without potash in the manure, the other two ingredients are of very little use, unless, indeed, the land be very rich in potash.

Potash salts alone may be a sufficient manure on land in good condition, and may even produce a fair crop on land that is in poor condition.

Phosphate, when applied along with potash salts, or when applied to land rich in potash, has a marked effect upon the crop.

Nitrogenous manures, even when of the most favourable kind, have very little influence in increasing the bean crop.

Lime, in the form of gypsum (or sulphate of lime), has a beneficial effect upon the crop.

Dissolved phosphate acts far more powerfully on the bean crop than ordinary ground phosphate.

Phosphatic guano was more effective than ground mineral phosphate, presumably for the reason that a small proportion of it was in an easily dissolved form.

The nitrogenous manures that are most beneficial to the bean crop are those whose action is rapid and soon over. In this respect nitrates are preferable to all other nitrogenous manures.

Nitrogenous manures should either be applied in very small quantity, or altogether withheld from the bean crop.

Nitrogenous manures that come into operation after the crop has made some growth have an injurious effect. Even sulphate of ammonia is too slow in its action, and retards the growth of the crop.

Nitrogenous manures should not be applied as a top-dressing to the bean crop.

Peruvian and other nitrogenous guanos are among the worst manures for the bean crop. They contain too much nitrogen and too little potash.

The muriate of potash has proved a more effective manure than the sulphate.

The beneficial effect of gypsum is to be ascribed, not to the sulphuric acid it contains, but to the lime, which, in combination with sulphuric acid, is a soluble manure, and has the power of liberating potash in the soil.

The general results of the experiments with different manures on the bean crop inform us that the bases potash and lime are the substances most required by the crop. The acids, phosphoric acid and nitric acid, are of secondary importance, and sulphuric acid is of no importance.

For land dunged in autumn—or for land in good condition—it would seem from the experiments at Pumpherston that the application of superphosphate, muriate of potash, and sulphate of lime, in equal parts, would be a very appropriate manure for the bean crop.

The composition of beans is very uniform whatever be the nature of the manures applied. It is the *quantity* of the crop, and not the *quality* of it, that is affected by the application of manures.

Lessons from Incomplete Manure Experiments.

The following are the amounts of dry vegetable matter yielded during eight years by those plots at Pumpherston from whose manures one or more of the three constituents—nitrogen, phosphoric acid, and potash—were withheld :—

	Tons per acre.
Nitrate and potash (no phosphate)	9.78
Nitrate and phosphate (no potash)	8.97
Potash and phosphate (no nitrogen)	7.65
Nitrate of soda alone . . .	8.68
Bone-ash alone	6.50
Potash salts alone	5.35
Unmanured	5.40

From these figures it is evident that the manurial constituent most required for the production of the crops grown was *nitrogenous matter*, in the next place *phosphates*, and in the next *potash*.

Potash alone.—The plot to which potash salts alone were applied gave scarcely as much produce as the unmanured plot.

This plot went steadily from bad to worse, and was latterly the worst on the station, showing that the accumulation of potash was hurtful to most of the crops grown there.

There was one exceptional year, 1884, when the crop was beans, and then for the first time it threw up a crop five times as abundant as the neighbouring plot, to which no potash had been applied.

An Experiment for Farmers.—An experiment of the above kind—in which, along with a completely manured plot, there are arranged side by side a series of plots from which in turn one of the essential ingredients of a complete manure is withheld—forms a most instructive lesson for farmers, and should be applied by them to all the fields on their farm. It serves to show what is the ingredient in the soil or in the manure that is most deficient for the production of a crop, and thus guides the farmer in the selection of the light manures that are most appropriate for his purposes.

Manures for different Crops.

A review of the manurial requirements of a rotation of crops, consisting of turnips, barley, beans, and oats, shows that while the three great constituents of a manure—nitrogen, phosphoric acid, and potash—are all required in order to raise full crops and to maintain the fertility of the soil, the predominance which should be given to one or other of these constituents varies with the crop. The predominant constituent is—for

Turnips—Phosphoric acid.
Barley and oats—Nitrogen.
Beans—Potash.

Relative Importance of the Constituents.—The relative importance of the three constituents for these three classes of crops must be arranged in the following manner :—

Turnips.	Cereals.	Beans.
1. Phosphoric acid,	Nitrogen,	Potash.
2. Nitrogen,	Phosphoric acid,	Phosphoric acid.
3. (Potash),	Potash,	(Nitrogen).

The constituents enclosed in brackets should not be applied to the crops to which they refer unless it has been learned by experiment or observation that the land is deficient in them, and that the crops are benefited by them, for it may happen that they have an injurious instead of a beneficial effect.

Regarding the forms in which the three constituents should be applied, reference must be made to the information given under each heading in the previous pages. But it may be shortly noted that—

Forms of Manures for Turnips.—For turnips the phosphates should be applied either in a soluble form or in a state of very fine division—in the case of ground phosphates, they should be at least so finely ground as to pass through a sieve of 120 wires to the linear inch,—or they should be of a kind that rapidly rot in the soil (such as bone-meal), and at the same time so finely ground as to permit of their being rotted in great measure during the period of the crop's growth. The nitrogenous manure should be partly of a quick-acting and partly of a slow-acting kind, so as to be of service to the crop during the whole period of its growth.

Forms of Manure for Cereals.—For cereals the nitrogenous manure should be very rapid in its action, so as not to retard the ripening of the crop. If applied as a top-dressing, it should consist of nitrate. The phosphate cannot be too rapid, and on that account superphosphate is to be preferred to any other form of phosphate.

The importance of potash in a cereal manure will depend on whether grass and clover seeds are sown with the crop. If that is the case, potash salts take the second place, as the presence of potash in the manure is of importance for the nourishment of clover.

Forms of Manure for Beans.—For the bean crop, the form of potash salt that is most suitable is the muriate of potash. Superphosphate is preferable to other forms of phosphate, probably on account of the large amount of sulphate of lime contained in that manure; but if sulphate of lime is applied to the crop, any other good phosphatic manure may form part of the mixture. The only kind of nitrogenous manure that is to be recommended for this crop is a soluble one, and that in small quantity, applied with the seed.

Dung for Turnips, Cereals, and Beans.—When farmyard manure is used for the turnip crop, potash salts should not be applied to it, and any nitrogenous manure added should be soluble.

The need which cereal crops have of nitrogen points strongly to the conclusion that a part of the dung should be withheld from the root crop and applied to the white crop; and this is all the more to be recommended, as it is evident that a considerable loss of the nitrogen of the dung is inevitable when a heavy dunging is applied to the fallow break.

If dung is to be used for beans, it should be applied to the stubble, rather than put in with the seed.

Organic Matter.

While it has been stated that on ordinary soils the three constituents—phosphoric acid, nitrogen, and potash—are sufficient to form what is known as a complete manure, and that a manure containing two of these substances, or, it may happen, only one of them, is a sufficient manure to apply to certain crops in certain circumstances, it is of the utmost importance here to observe that, nevertheless, it must not be supposed that, in the manipulation of these three constituents, in reference to the crops they are producing, lies the whole question of manuring.

Consider Soil as well as Manure and Crop.—The rapidity with which light manures act upon the crops to which they are applied has tended to restrict our view too much to the two factors—manure and crop—and has caused us to think less of the *soil* than our forefathers did.

Before the days of light manures—a time comparatively recent—when the wants of a crop for phosphates, nitrates, and potash were unknown, farmers fixed their attention upon the soil, and used

every means to raise its general fertility —to put it into what is called high "condition"—and this they did by the use of heavy manures containing a large amount of organic matter.

Function of Organic Matter.—It has since been discovered that plants can grow to perfection without organic matter, but the circumstances in which that is possible for crops are not those which prevail in ordinary farming and in this climate.

It is to the organic matter in the soil that are due many of the changes going on there that are beneficial to the roots of plants. The warmth and moisture of the soil are increased by the organic matter in it, and the acids formed by its decay have an important part to play in dissolving the mineral matter, which forms the food of plants. It is indeed the key to the treasures of the soil. But in the ordinary operations of agriculture —in the constant disturbing and working of the ground—organic matter is rapidly destroyed, so that if farmyard manure and organic composts or other substances rich in organic matter are not put into land under cultivation, or fed on it, it soon becomes unduly deprived of organic matter. And the soil is thus deteriorated as a medium for the growth of roots and for the retention of moisture, and as a store of fertility gradually becoming available for the nourishment of crops.

During very dry or cold seasons, and even during very wet ones, the want of organic matter in the soil is a source of danger to the crop. The fate of many plots at the stations during the recent drought showed how intimately the fertility of the land, and the health and safety of the crop, are concerned in the accumulation of organic matter in the soil.

Quick-acting Manures and Organic Matter.—However much, therefore, we may commend the application of quick-acting light manures—phosphates, nitrates, and potash salts—for the assistance of crops, it is quite evident that their proper position on most kinds of land is subordinate to that of the heavier manures and to the slowly acting manures rich in organic matter, which perform the important work of building up the fabric of the soil, and accumulating therein a reserve of fertility which is commonly known under the name of "condition," and which is also called "backbone" by those who are able to appreciate its importance.

Numerous other experiments of importance have been conducted throughout the country, both by societies and individuals, all of which have contributed to the fund of knowledge relating to the great subject of manuring. The Royal Agricultural Society of England, and the Bath and West of England, have been, and still are, specially prominent in this good work. In different sections of *The Book of the Farm*, notably in those relating to foods, and to the feeding of stock, reference has been made to the Woburn feeding experiments of the former society; and the manuring experiments there, although not as yet so conclusive as could be desired upon the main points under special investigation, are likewise interesting and important.

SEED-TIME.

The "seed-time" is a season of continual stir and bustle on the farm. The prognostics and variations of the weather are watched with the keenest interest and anxiety, for not only the progress of the spring work, but also the returns of the harvest are greatly influenced by the character of the weather during the seed-time.

Seasonable Working of Land.—Field-work will now be pushed on with all possible speed. Yet there are more points to be considered than the mere progress of the work. In particular, care must be exercised as to the condition in which the different kinds of soils are tilled and prepared for the crops. To stir stiff clay when it is soaked with wet

would be ruinous. Better delay a little than commit the seed to a cold, unkindly, ill-prepared seed-bed. Better let the men and horses stand idle for a few days than run the risk of destroying the year's produce by working the land in an unseasonable condition. On the other hand, when the weather is favourable, and the land in good condition for tillage operations, let all hands do their very best, so that full advantage may be taken of every favourable spell of weather.

Selecting Seeds.

Farmers cannot be too careful in the selection of seeds. It matters not what the crop may be, the best possible seed should be secured. To ensure thoroughly reliable seeds of a high character, an extra outlay of a few shillings per acre may be entailed, but then these *few shillings* may add pounds to the value of the crop.

Improvement in Seeds.—In this matter of seeds, the farmers of the present day are well situated compared with their brethren in former times. The development of the Seed industry is indeed one of the most notable—one of the most beneficial—features in the progress of modern agriculture. The improvement of the animals of the farm has been accomplished on the farms by the stock-owners themselves. Equally important and equally great in its way has been the improvement of the plants of the farm. And this latter work has been carried out in the most thorough and energetic manner by a number of extensive and influential seed firms, who have for many years devoted great attention not only to the improvement of the old varieties of the farm crops, but also to the propagation and development of new varieties of increased producing power. There are many eminent firms who have in this way rendered good services to the country. Amongst the names most prominently associated with this great work of plant improvement are those of Sutton, Carter, Webb, Drummond, and Dickson; but there are several other firms which have also been active in similar well-doing.

The part which these enterprising firms, who give us the improved, selected, and tested seeds, have played in the progress of modern agriculture, has been greater by far than is generally recognised. It has, of course, been a matter of business, not of philanthropy with them; all the same, it is right to acknowledge the great power which the development of the seed trade has exercised in the advancement of agriculture.

An Extensive Seed Firm.—The fact that the work which the leading "specialist" seedsmen have been engaged in is of advantage to the farmer, is indicated by the vast proportions which the business of a few of these firms has attained. The business premises occupied by Messrs Sutton & Sons, Reading, cover no less than six acres of ground. This firm, established in 1806, is now the largest of its kind in the world. At its experimental grounds at Reading thousands of trials with farm and garden seeds are made every year, and anything of special promise is chosen for stock, and is in due time, when by further culture the "type" becomes sufficiently fixed, propagated extensively for sale. In this way, by this and other firms, many valuable varieties of grain, roots, vegetables, and other plants have been placed in the hands of the farmer. During the busy seed season, from January 1 till end of April, the number of letters reaching Messrs Sutton & Sons' establishment average from 1200 to 1600 per day; while the letters despatched range from 1800 to 2000 daily. From 700 to 800 seed orders have to be executed every day in the height of the season. The accounts opened to customers approach 70,000 in number, and it is curious to note that amongst these are no fewer than 800 with the name of Smith!

With the excellent facilities that are thus provided by the leading seed firms for procuring high-class seeds of proved purity and germination, farmers now run little risk of loss by weak or impure seed. They should in all cases see that they obtain seeds which have been tested for their vitality, and which are well cleaned and true to their kind. These remarks apply equally to all kinds of seeds; and once again we would remind the farmer that a few shillings for first-class seed may add pounds to the value of the produce.

Sowing is sometimes delayed by dila-

toriness on the part of the farmer in providing the necessary supplies of seeds. Have these on the farm *before* they are required, so that they may be at hand when a suitable time arrives for sowing.

Change of Seed.—It is well known amongst practical farmers that great advantage may be derived by judicious change of seed. As a rule with roots, fresh seed is introduced every year, for it is only in exceptional cases where the farmer grows his own turnip-seed. With grain, however, the rule is reversed. The home-grown seed is used for the most part; but it has been clearly shown that by an occasional change from one climate, one soil, and one system of farming to another, the vitality and producing power of a particular kind or "stock" of grain are substantially increased. When one considers the artificial influences by which our improved varieties of grain have been brought to their highly developed condition, one cannot be in the least surprised that such changes of scene and surroundings should often exercise a beneficial effect upon the crop.

But all changes are not successful. Neither are the conditions essential to success very fully known. In almost every change of seed, as in every change of a sire, there is something of the nature of an experiment. As a rule, a change of seed from an early to a late district is followed by a marked benefit, notably in the earlier ripening of the crop, but also to some extent in the quantity and quality of the produce. The influence on the date of the harvest is most marked. For instance, by the habitual introduction of seed-oats from the south of Scotland every second or third year, the ripening of the crop on certain farms in the later districts of the north-east has been hastened by from six to ten days; and practical farmers acquainted with a late climate know that acceleration to that extent in harvest is a very important advantage — perhaps all the difference between a crop secured and a crop partially lost. The weight of the grain will also most likely be increased 2, 3, or more pounds per bushel. Then in taking seed from a late to an early district there may sometimes be an advantage—notably an increase in the bulk of the produce.

A good plan in changing seed is to try the change on a small scale in the first year, and if the results are satisfactory, use the variety more extensively in subsequent years. Farmers should be experimenting in this way very frequently, for by introducing fresh varieties well suited to their land, the produce of their crops may be substantially increased. A change of seed from a clayey to a light loamy or sandy soil is generally beneficial.

New Varieties of Farm Plants.—Farmers also derive much benefit by taking advantage of the many new and improved varieties of grain and roots which are brought out by experimenting seedsmen. Our leading seedsmen are continually engaged in propagating fresh and improved varieties of farm crops, more particularly of grain, mangels, swedes, turnips, and potatoes, and by availing themselves of these new and vigorous sorts of proved excellence, farmers may to a marked extent enhance their produce.

At the same time, it is well to say that caution should be exercised in introducing new varieties. Let them be tried on a small scale at the outset, and adopted extensively only after their suitability and high qualities have been unmistakably established.

Testing Seed.—Farmers should carefully avoid using *weak* or *unreliable* seed. Seeds of all kinds may now be procured pure, and of certain germination. This should always be insisted upon, and farmers should themselves test the seeds when they take them home. Even home-grown seed, however well it may look, should never be sown without having been first carefully tested. This may be done very easily with grain or grass seeds, by placing say a hundred seeds between two folds of damp blotting-paper laid on a meat or soup plate, with another similar plate placed face downwards over that plate. No artificial heat need be used, and the plates may sit on an open shelf in the farmer's parlour. The blotting-paper should be damped every day by sprinkling a little water on it by the hand. The object of having the two plates placed face to face is to cause a current of air to pass over the seeds. In this way cereal seeds will germinate in about a week, and grass-

seeds in about three weeks. An efficient testing apparatus may be purchased at a moderate cost.

Grain-seeds are often tested under a very thin damp turf in a well-exposed spot in the farmer's garden. We have also seen it done on damp turfs, placed on the rafters over the heads of cattle, where, of course, the temperature is considerably higher than outside early in spring, when testing is usually carried out.

Clover, *turnip*, or any other leguminous seeds may be tested in a more simple and expeditious manner. Count out say 100 seeds, roll them into a piece of flannel, and dip into boiling water for four or five minutes, and on opening the piece of flannel all the reliable seeds will be found much swollen, and actually germinated, with the elementary root shooting out. The seeds which do not present this swollen appearance cannot safely be reckoned upon, and the quantity of seed to be given per acre should be regulated by the percentage of the reliable germinating seeds.

SOWING SPRING WHEAT.

A large extent of wheat is sown in spring after a crop of roots of one kind or another.

Good Land for Wheat.—To ensure a good crop of spring wheat, the land should be for some time in good heart, otherwise the attempt will inevitably end in disappointment. Wheat cannot be sown in spring in every weather and upon every soil. Unless the soil has a certain degree of firmness from clay, it is not well adapted for the growth of wheat—it is more profitable to sow barley upon it; and unless the weather is dry, to allow strong soil to be ploughed in early spring, it is also more profitable to defer wheat, and sow barley in the proper season. The climate of a place affects the sowing of wheat in spring; and it seems a curious problem in climate why wheat sown in autumn should ripen satisfactorily at a place where spring wheat will not. Experience makes the northern farmers chary of sowing wheat in spring, unless the soil is in excellent condition, and the weather very favourable for the purpose.

Date of Sowing.—In former times, even under the most favourable circumstances, wheat was seldom sown after the first week of March, but later varieties have been introduced which may be sown as late as April.

On farms possessing the advantages of favourable soil and climate, and on which it is customary to sow spring wheat every year, the root-land is usually ploughed with that view up to the beginning of March; and even where spring wheat is sown only when a favourable field comes in the course of rotation, or the weather proves tempting, the land should still be so ploughed that advantage may be taken to sow wheat. Should the weather take an unfavourable turn after the ploughing, the soil can afterwards be easily worked for barley.

Tillage for Wheat.—The land should receive only one furrow—the seed-furrow—for spring wheat, because if ploughed oftener, it would be deprived of that firmness so essential to the growth of wheat. The mode of ploughing this seed-furrow depends upon circumstances. If the land has a visible form of ridge, and easily becomes wet, it should be gathered up (fig. 34, p. 110, vol. i), and then it will have the appearance of being twice gathered up, as in fig. 40, p. 115, vol. i. If the land is flat, and the subsoil somewhat moist, gathering up from the flat will answer best, as in fig. 34. If the soil has a dry subsoil, though of itself a pretty strong clay, it may be cast with gore-furrows (figs. 36 and 37). And should the land be fine loam, resting on an open bottom, the ridges may be cast together without gore-furrows, as in fig. 36.

It is probable that a whole field may not be obtained at once to be ploughed, and this often happens for spring wheat; but when it is determined to sow wheat, a few ridges should be ploughed as convenience offers, and then a number of acres may be sown at one time. In this way a large field may be sown by degrees, whereas to wait till a whole field can be sown at once, may prevent the sowing of spring wheat that season. Bad weather may set in, prevent sowing, and consolidate the land too much after it had been ploughed; still a favourable week may come, and, even at the latter end of

the season, the consolidated land can be ribbed with the small plough, which will move as much of the soil sufficiently as to bury the seed.

Double-furrow Plough.—To expedite the ploughing of the seed-furrow at a favourable moment, the double-furrow plough is used by some, though not so largely now as a few years ago. One form is represented in fig. 255 (made by Fowler & Co. on Pirie's Patent), and another in fig. 256, made by J. Cooke & Sons, Lincoln.

Advantages of the Double-furrow Plough.—The double-furrow plough is usually worked with 3 horses, and as to the question whether it effects a saving of draught as compared with two single

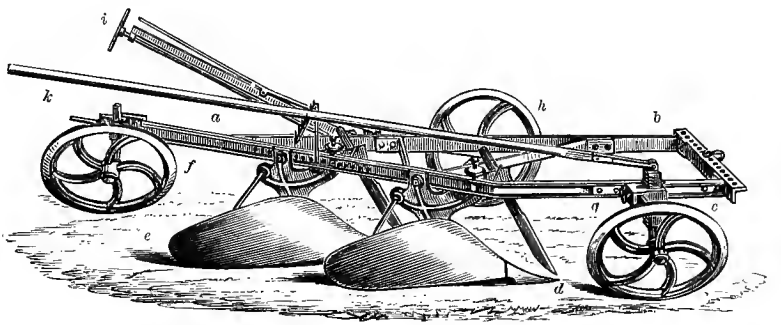


Fig. 255.—*Fowler's double-furrow plough with single lever.*

a to *b* Frame of wrought-iron flat bar.
a to *c* Frame of angle iron.
d Front plough fixed, with mould-board, coulter, and share.
e Hind plough, movable, with like mounting.
f g Inclined wheels with angular rims.
h Vertical wheel with angular rim.
i Handle and screw-rod.
k Lever for adjusting wheel *g*.
b c Cross or front bar acting as the bridle.

furrow-ploughs, there has been much discussion. Experiments with the dynamometer have shown that there is little saving in this respect, and that the 3 horses have to exert about as much force as 4 horses, with 2 common ploughs doing the same amount of work, with a slight difference in favour of the double-furrow plough. In a trial with the double-furrow plough and others in 1870, the common plough, with a furrow of from 6½ to 7½ inches deep, gave a draught from 4 to 5 cwt.; while 9 double-furrow ploughs, with an average depth of furrow of 5½ inches, gave an average draught of 7 cwt.

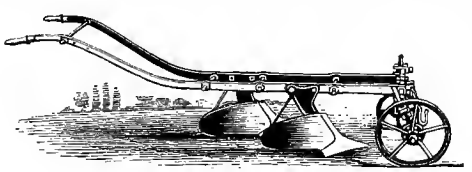


Fig. 256.—*Cooke's double-furrow plough.*

In regard to saving either men or horses in employing the double-furrow plough, a writer says: "It is a mistake to suppose, as many do, that the double-furrow plough saves 1 man and 1 horse. Turning over 2 furrows, and presuming the plough to be drawn by 3 horses (it is too fatiguing for 2 horses), it undoubtedly saves 1 horse and its keep, but it does *not* save a man. Two double ploughs might, indeed, be managed by 6 horses and 2 men, and thus a saving be effected of 1 man and 2 horses—that is, if farmers can get ploughmen to undertake the grooming of 3 horses. Most of them think they have enough to do with 2 horses, and it can hardly be expected that they will add a third to their labours without something like a corresponding addition to their wages. At the best, therefore, it will be seen that the new ploughs can save only 1 man out of 3, and of horses 2 out of 8, in turning over 4 furrows. But men at certain seasons of the year are needed on the farm for other work than ploughing, and it is perhaps doubtful whether the double ploughs will effect more than the saving of horses. This alone is a great matter." [1]

[1] *The Farmer*, January 26, 1870.

In recent years double-furrow ploughs have been losing favour in many parts of the country where they obtained a footing. The modern Anglo-American plough is now preferred by many for speedy ploughing. Still, in some circumstances, the double-furrow plough may be employed with advantage.

Several improvements have lately been effected in the double-furrow ploughs, and now they are, as a rule, lighter in draught, and more easily manipulated than in former times.

Sowing. — The land, having been ploughed, should be sown at once. To economise time, the seed-wheat should have been measured up in the sacks, or ready to be measured up in the corn-barn or granary, and, if pickling is to be done, the means of doing it provided.

Quantity of Seed.—Wheat should be sown thick in spring, as there is no time for the plant to *stool* or *tiller* —that is, to throw up a number of young shoots from one root, as is the case with autumnal-sown wheat. About 3 bushels per imperial acre will suffice of seed for spring wheat, but many farmers sow a little more. There is always a controversy about thick and thin sowing. Since spring wheat does not tiller, it stands to reason that it should be sown thick and buried regularly under the surface, which is most efficiently done by a drill-machine.

Pickling Wheat.—There is much to be said in favour of the *pickling* of seed-*wheat*—that is, subjecting it to a preparation in a certain kind of liquor—before it is sown, in order to ensure it against the attack of a fungoid disease in the ensuing summer, called *smut*, which renders the grain comparatively worthless. Some farmers affect to despise this precaution, as originating in an unfounded reliance on an imaginary specific. But the existence of smut, and its baneful effect upon the wheat crop, are no imaginary evils; and when experience has proved, in numberless instances, that steeped seed protects the crop from this serious disease, the small trouble and expense which pickling imposes may surely be incurred, even although it should fail to secure the crop. *How* pickling the seed prevents the smut in the crop, is a question more easily asked than answered; and it is, perhaps, from the want of a satisfactory answer that pickling is disregarded by incredulous farmers. Objection against the practice is as difficult to be stated as any reason for it, but the palpable fact stands uncontradicted, that one field sown with pickled wheat, and otherwise managed in the usual way, will most likely escape the smut; while the adjoining field, managed in exactly the same way, but sown with wheat without pickle, will most likely be affected more or less with the disease.

Various methods and materials for pickling are employed. A solution of blue vitriol is now most generally used, and the process, as described in former editions of this work, is seen in fig. 257.

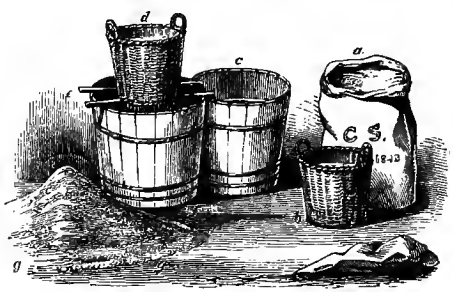


Fig. 257.—*Apparatus for pickling wheat.*
a Sackful of wheat.
b Basket to receive the wheat from the sack.
c Tub of pickle.
d Basket of pickled wheat.
e Drainer for basket.
f Tub to receive draining of pickle from the basket.
g Heap of pickled wheat.
h Sacks for the pickled wheat.

The pickling may be done on a part of the corn-barn floor. Two upright baskets are provided, each capable of holding easily about half a bushel of wheat, having upright handles above the rims. Pour the wheat into one basket from the sack, and dip the basketful of wheat into the tub of vitriol completely to cover the wheat, the upright handles protecting the hands from the vitriol. After it remains in the liquid for a few seconds, lift up the basket, so as to let the surplus liquid run from it into the tub again, and then place the basket upon the drainer on the empty tub, to drip still

more liquid, until the other basket is filled with wheat and dipped in the vitriol tub. Then empty the dripped basket of its wheat on the floor, and as every basketful is emptied, let a person spread, by riddling it through a wheat-riddle, a little slaked caustic lime upon the wet wheat to dry it. Thus all the wheat wanted at the time is pickled and emptied on the floor in a heap.

Turning Pickled Wheat.—The pickled and limed heap of wheat is turned over and mixed in this way: Let two men be each provided with a square-mouthed shovel (fig. 114, p. 234, vol. i.), one on each side of the heap, one having the helve of his shovel in his right hand, and the other in his left; and let both make their shovels meet upon the floor, under one end of the heap of wheat, turning each shovelful from the heap behind them, till the other end of the heap is reached. Let them return in a similar manner in the opposite direction, and continue, until the wheat is thoroughly mixed and dried with the lime. The pickled wheat is then sacked up, and carried to the field in carts.

Seed-dressing to Ward off Birds.—A Surrey farmer says: "We are much troubled with crows and other birds eating the seed of wheat and other grain, but wheat more especially. The crows do most damage just when the plant begins to come through the soil. I have tried various dressings for the seed, but found the following by far the most effectual in warding off the crows: For one quarter of wheat take a two-gallon pail, into which put quarter full of fresh lime, mixing and stirring with hot water, just enough water to get it into a thick paste; then put in one pint of tar; stir all up together, and fill up the pail with water, and keep stirring. Pour this over the heap of seed, and keep stirring till all the seed is equally stained with the mixture. This is also effectual for barley, but no use for oats, as the birds can pick out the kernel."[1]

There are several most useful preparations for pickling wheat, not only for preventing smut, but also for preventing insects and crows and other birds from eating the seed. Chief among these special preparations are Down's "Farmers' Friend" and Clarke's and King's specifics.

Placing Sacks in the Field.—There is some art in setting down sacks of seed-corn on the field. The plan of placing the sacks of course depends on whether the seed is to be sown by the hand or by a machine. The sacks are set down across the field from the side at which the sowing commences. One row of sacks is sufficient, when the ridges are just long enough for the sower to carry as much seed as will bring him back again to the sack, and the sacks are then set in the centre of the ridge. When the ridges are short, the sacks are set upon a head-ridge; and when of such length as the sower cannot return to the sack by a considerable distance, two rows of sacks are set, dividing the length of the ridges equally between them, setting the two sacks on the same ridge. The sacks are placed upon the furrow-brow of the ridge, that the hollow of the open furrow may give advantage to the carrier of the seed to take it out easily as the sack becomes empty. In thus setting down the sacks of seed, it is intended to give the supply of seed more easily to the man who sows the seed by hand.

When a machine is employed to sow the seed, the sacks are set upon one of the head-ridges connected with the gate of the field, unless the field is so long that a row of sacks must be placed in the middle.

Where to begin Sowing.—If the surface is level, it matters not which side of the field is chosen for commencing the sowing; but if inclined, the side which lies to the left on looking down the incline should be the starting point. The reason for this preference is, that the first stroke of the harrows along the ridge is most difficult for the horses to draw; and it is easiest for them to give the first stroke *downhill*. This first action of the harrows is called *breaking-in* the land. It is the same to the sower at which side he commences the sowing, but ease of work for the horses ought to be studied.

Seed Carrier.—In Scotland the carrier of the seed is usually a woman, and the instant the first sack of seed is set down, she unties and rolls down its mouth, and fills the *rusky*, basket, pail,

[1] *Farming World*, p. 471. 1887.

or whatever she uses in conveying the seed, and carries it to the sower, who awaits her on the head-ridge from which he makes his start. Her endeavour should be to supply him with such a quantity of seed at a time as will bring him in a line with the sack where he gets a fresh supply; and as the sacks are placed half-way down the ridges when only one row is set down, this is easily managed; but with two rows of sacks, she must go from row to row and supply the sower, it being her special duty to attend to his wants, and not to consider her own convenience. Nothing can be more annoying to a sower than to have his sheet or sowing-basket served too full at one time, and too stinted at another; as also to lose time in waiting the arrival of the seed-carrier, whereas she should be awaiting his arrival. When two rows are at a considerable distance, on long ridges, two carriers are required to serve one sower. Better that the carriers have less to do than that the sower lose time and delay the harrows, which will likely occur when the carriers are overtaxed.

Seed-basket.—The basket or vessel in which the carrier conveys the seed is of various patterns—a deep or shallow basket, or ordinary pail, sometimes carried on the head, and in other cases in the hand or on the arm and haunches. The seed is most easily poured into the sowing-basket from the seed-basket on the head. It should be filled each time with just the quantity of seed the sower requires at a time.

The Seed-sacks.—The mouth of the sack should be kept rolled down, that the seed may be quickly taken out, for little time is usually at the disposal of the carrier. The carrier should be very careful not to spill any seed upon the ground on taking it out of the sack, otherwise a thick tuft of corn will unprofitably grow upon the spot. As one sack becomes empty, the carrier should take it to the nearest sack; and as the sacks accumulate, they should be put into one, and carried forward out of the way of the harrows. It is a careless habit which permits the sacks to lie upon the ground where they are emptied, to be flung aside as the harrows come to them.

One-hand Sowing.—In former times the sower by hand in Scotland was habited in a peculiar manner. He sowed by one hand only, and had a sowing-sheet wound round him, as shown in fig. 258. The most convenient sheet is of linen. It is made to have an opening large enough to admit the head and right arm of the sower through it, and a portion of the sheet to rest upon his left shoulder. On distending the mouth of the doubled part with both hands, and receiving the seed into it, the loose part of the sheet is wound tight over the left hand, by which it is firmly held, while the load of corn is supported by the part of the sheet which crosses the breast and passes under the right arm behind the back to the left shoulder. A *basket* of wicker-work, such as fig. 259, was very common in England for sowing with one hand. It was suspended by a girth fastened to two loops on the rim of the basket, and passing round the back of the neck; the left hand holding the basket steady by the wooden stud on the other side of the rim.

Fig. 258.—*Sowing-sheet and hand-sowing corn.*

Two-hand Sowing.—But the system

of sowing with both hands is now more general than one-hand sowing. It should indeed be the universal method wherever hand-sowing is pursued. It is the most expeditious; and many people consider that the sowing can be done more evenly with two hands than with one.

For two-hand sowing a simple form of sowing-sheet is a linen semi-spheroidal

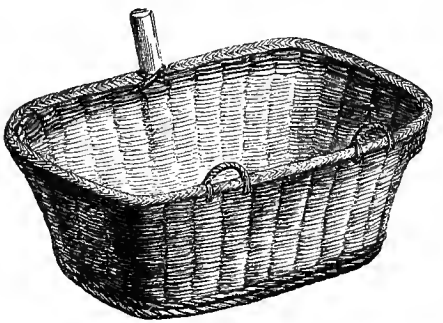


Fig. 259.—*English sowing-basket.*

bag, attached to a hoop of wood or of iron rod, formed to fit the sower's body, buckled round it, and suspended in front in the manner just described. Both hands are thus at liberty to cast the seed, one handful after the other.

Art of Sowing.—The following detailed description of the art of sowing by one hand is also so far applicable to sowing by both hands. Taking as much seed as he can grasp in his right hand, the sower stretches his arm out and a little back with the clenched fingers looking forward, and the left foot making an advance of a moderate step. When the arm has attained its most backward position, the seed is begun to be cast, with a quick and forcible thrust of the hand forward. At the first instant of the forward motion the fore-finger and thumb are a little relaxed, by which some of the seeds drop upon the furrow-brow and in the open furrow; and while still further relaxing the fingers gradually, the back of the hand is turned upwards until the arm becomes stretched before the sower, by which time the fingers are all thrown open, with the back of the spread hand uppermost. The motion of the arm being always in full swing, the grain, as it leaves the hand, receives such an impetus as to be projected forward in the form of a figure corresponding to the sweep made by the hand. The forward motion of the hand is accompanied by a corresponding forward advance of the right foot, which is planted on the ground the moment the hand casts forward the bulk of the seed.

The action is well represented in fig. 258, except that some would consider the sower should give his hand a higher sweep, especially on a calm day. The curve which the seed describes on falling upon the ground, is like the area of a portion of a very eccentric ellipse, one angle resting on the open furrow, and the other stretching 2 or 3 feet beyond the crown of the ridge, the broadest part of the area being on the left hand of the sower.

The moment the seed leaves it the hand is brought back to the sowing-sheet to be replenished, while the left foot is advanced and the right hand is stretched back for a fresh cast, and thrown forward again with the advance of the right foot.

The seed ought to be cast *equally over the ground.* If the hand and one foot alternately do not move simultaneously, the ground will not be equally covered, and a strip left between the casts. When the braird—that is, the young plants—comes up, these strips show themselves. This error is most apt to be committed by a sower with a stiff elbow, who casts the grain too high above the ground. The arm should be thrown well back and stretched out, though, in continuing the action, with the turning up the back of the hand, the inside of the elbow-joint becomes pained.

If the hand is opened too soon, too much of the seed falls upon the furrow-brow, and the crown receives less than its proportion. This fault young sowers are very apt to commit, from the apprehension that they may retain the seed too long in the hand. If the hand is brought too high in front, the seed is apt to be caught by the wind and carried in a different direction from that intended.

When the wind becomes strong, the sower is obliged to walk on the adjoining ridge to the windward to sow the one he wishes; and the sower should cast low in windy weather.

Some sowers take long steps, and make

long casts, causing some of the seed to reach across the ridge from furrow to furrow. Such a sower spills the seed behind the hand, and makes bad work in wind. The step should be short, the casts frequent, and the seed held firmly in the hand, then the whole work is under complete command. The sower should never bustle and try to hurry through his work; he should commence with such a steady pace as to maintain it during the day's work.

A sower with *both hands* makes the casts alternate, the hand and foot of the same side moving simultaneously with regularity and grace.

Sowing-machines. — Hand-sowing has been to a large extent superseded by sowing-machines. These do the work better than it can possibly be done by hand, and their use is therefore to be commended. Of seed-sowing machines there are many patterns, some dropping the seed in drills, others scattering it broadcast. A material difference exists between these two classes of machines. The broadcast machine deposits the seed upon the surface of the ground, and is in fact a direct substitute for hand-sowing; and as it deposits the seed very regularly, this machine is now extensively used.

The *drill-machine* deposits the seed at once at a specific depth under ground in rows, and at such distances between the rows, and with such thickness in the rows, as the will of the farmer may decide.

The seed being left by the broadcast machine on the ground like hand-sowing, is buried in the soil more or less deeply as the harrows may chance to take it; whereas the drill-machine deposits the seed in the soil at any depth the farmer chooses, and all the seed at the same depth, thereby giving him such a command over the position of the seed in the soil as no broadcast machine or hand-sowing can possibly do.

Broadcast Sowers.—There are various forms of the *broadcast* sowing-machine. The one illustrated in figs. 260 and 261, made by Ben. Reid & Co., Aberdeen, exhibits the machine in the most perfect form, not only doing the work easily and well, but is so constructed that its long sowing-chest is divided into sections, the two end ones of which can be folded upon the central division, whereby the machine may pass through any field-gate without having to remove the sowing-chest.

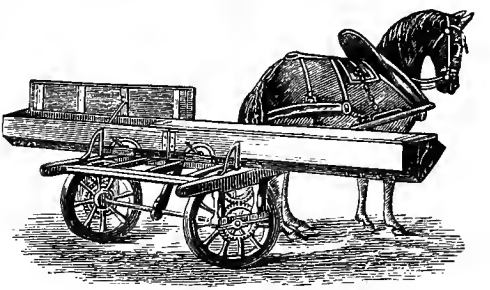


Fig. 260.—*Broadcast sower ready for work.*

By the use of the drill-machine less seed will thus suffice, and another advantage is that the land between the rows may be hoed by the hand-hoe, or by a horse-hoe, such as in fig. 262 (Kells, Meats, & Co., Gloucester), thus tending to clean the land. Drilling is rightly enough in favour for good land in good heart, but on poor or medium land it does not give so much straw as broadcast sowing. The *sowing-gear* of the broadcast machine is

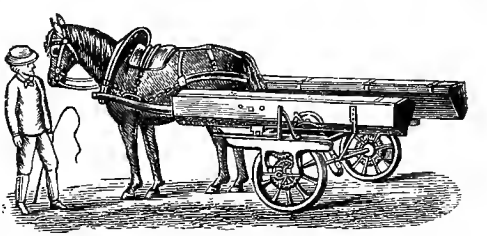


Fig. 261.—*Broadcast sower in transit*

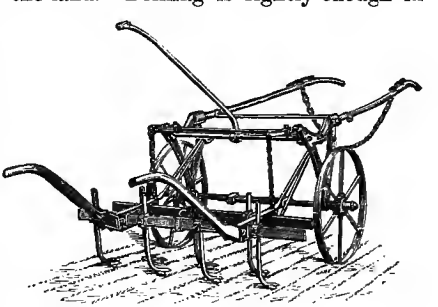


Fig. 262.—*Horse hoe.*

connected with the main axle of the carriage, as shown in the figure. The arrangements for regulating the quantity of seed per acre are very simple and effective, and altogether the machine is very easily worked and controlled. About 18 feet is the usual width sown at once by the machine.

Hand Broadcast Sowers.—Fig. 263 represents a very ingenious and most useful hand broadcast sower, the "Little Wonder," of American invention, and brought to this country by Mr J. H. Newton, West Derby, Liverpoool. The illustration pretty well explains its appearance and action. A light box of thin wood is carried under the left arm with a strap over the shoulder. To the top part of this is attached a canvas receptacle for the seed, while on front

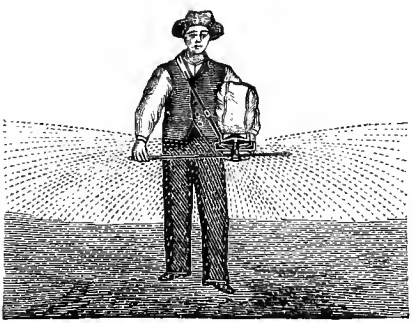


Fig. 263.—*Broadcast hand-sower*

and below is fixed a little tinned iron wheel, or rather four crossed pieces revolving on a spindle. Round this spindle is passed a thong which forms the string of a bow, and by "see-sawing" this bow the wheel revolves in alternate directions. An eccentric on the spindle moves a little hopper which keeps a regular stream of seed falling on to the revolving "wheel," and this in its turn sends the grain spinning out all round. It will cover a width of about 30 feet, but some have found it best in practice to go up the centre of one rig and down another, thus taking 14 or 16 feet at a time. It is thus possible, if kept supplied with seed, to do four acres per hour, while three is easy of attainment. To ensure an even braird, the machine should be carried in a level position. It sows all kinds of grain admirably, and is equally well adapted for sowing dry artificial manure.

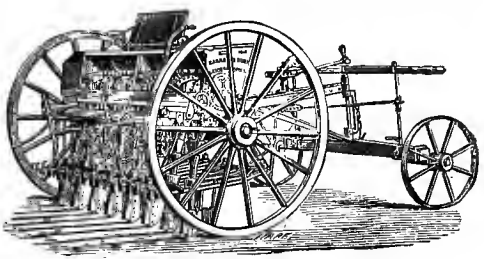


Fig. 264.—*Corn and seed drill.*

The quantity to be sown per acre is regulated by a little slide.

Strawson's ingenious air distributor may also be adapted for sowing grain broadcast.

Drill Sowers.—There are many patterns of these, and they are now very reliable in working. Ingenious and efficient devices are employed for regulating the quantity of seed per acre, the width of the drills, and the depth to which the seeds are deposited. Fig. 264 represents the improved Suffolk corn and seed drill made by R. Garrett & Sons, Suffolk.

The "Excelsior" drill-sowing machine (The Chadburn Manufacturing Company), represented in fig. 265, is a most ingenious American invention, designed to sow almost all kinds of farm seeds, as well as manure.

Width of Drill.—The width between the rows of wheat varies somewhat.

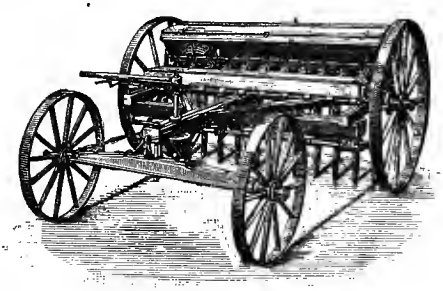


Fig. 265.—"*Excelsior*" *seed drill.*

On good land in high condition, 9 inches is a common width, but many

consider that rather too great for ordinary land.

Hand Seed-drill.—There are small hand seed-drills both for grain and root crops. Fig. 266 represents R. Boby's very useful drill of this pattern.

Fig. 266.—*Hand seed-drill.*

Harrowing.—The land, whether sown by hand or with any sort of machine, must be harrowed. The order in time of using the harrows differs with the sort of machine used for sowing the grain. When the grain is sown by hand or with the broadcast machine, the harrow is used chiefly after the grain has been sown, although many consider it desirable to "break in" the surface by a single or double turn of the harrows before sowing. But in sowing with drill-machines, the harrow is first used to put the land into the proper tilth for the machine.

Considering the operation the *harrow* has to perform in covering the seeds that have been cast upon the soil, and reducing the surface-soil to a fine tilth, it is an implement of no small importance; and yet its effects are apparently rude and uncertain, while its construction is of the simplest order. So simple indeed is this construction, that at a very remote period it appears to have taken that form which, in so far as the simple principles of its action are concerned, is almost incapable of further improvement.

Iron Harrows.—Fig. 267 represents Howard's set of iron harrows for a pair

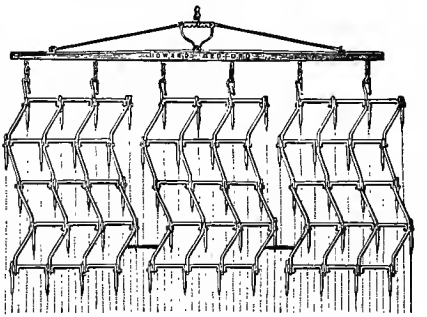


Fig. 267.—*English iron harrows.*

of horses. Sellar's harrows, suited for heavy land, are shown in fig. 268. Wooden harrows, once so common, are now out of date. Iron harrows are made of many patterns. Most of them are wonderfully durable, light in draught, and very effective in reducing the soil to a fine condition. They are made

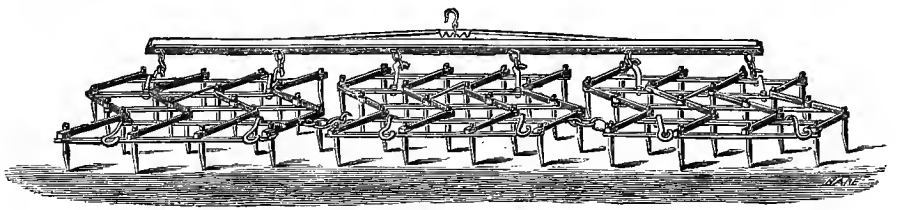


Fig. 268.—*Scotch iron harrows.*

heavy or light, according to the work intended to be done. In some the teeth or tines are held in by screw and nut, and in others by being driven through holes of the required size.

Process of Harrowing.—Two pairs of harrows work best together, their united breadth covering the entire ridge, and lapping over the crown where the soil is thickest. One pair takes the lead, by going usually on the near side of the ridge, while the other pair follows on the off side, but the leader takes the side of the ridge whichever is nearest the open field. Each pair of harrows should be provided with double reins, one rein from each horse; and the ploughmen should be made to walk and drive their horses with the reins from behind the harrows. If a strict injunction is not laid upon them in this respect, the two men may be found walking together, the leading one behind the harrows, the other at the head of his horses. The latter is thus unable to know whether his harrows cover the ground which they ought to

cover, and the two are more engrossed in talk than in the work in hand.

To draw harrows as they should be drawn, is really not so light work for horses as it seems to be. When the tines are newly sharpened and long, and take a deep hold of the ground, the labour is considerable. To harrow the ground well—that is, to stir the soil so as to allow the seed to descend into it, and bring to the surface and pulverise all the larger clods, as in the case of broadcast sowing—requires the horses to go at a smart pace; and for efficient working harrows should on all occasions be driven with a quick motion.

When the seed is sown by a drill-machine, it is deposited at a given depth; and in order that the harrows shall not disturb its position, the land is harrowed fine before the seed is sown, a single tine—that is, one turn of the harrows—along the drills covering the seed sufficiently.

Harrowing on Incline.—In harrowing after the broadcast seed, one must be guided by the circumstances of the case. If the harrowing commences at the foot of the incline, and with two pairs of horses, the following plan is adopted by some. The ridge next the fence should be ascended by the 2 pairs of harrows; and on gaining the top of the incline, the second ridge is descended, to break-in its seed; and *hieing*—that is, turning them round to the left—both the pairs of horses at the foot, the first ridge is again ascended, which finishes its double tine; and though both tines (or stripes or courses of the harrow) have been given on it in the same direction, the anomaly is submitted to in order to gain a favourable position for the horses to break-in the seed, which is from the top of an incline where there is an incline. *Hieing* the horses again on the upper head-ridge, the third ridge is broke-in down-hill; and *hieing* again on the lower head-ridge, the second ridge is ascended, and is thus finished in its double tine—given in opposite directions.

Thus by *hieing* both pairs of harrows at both ends, one ridge is broke-in on going down, and another receives the double tine on coming up the incline, which affords an easy mode of working the horses.

Suppose the harrowing had begun at the top of the declivity, the breaking-in commences at once on going down-hill; and to preserve the propriety of giving the double tines in opposite directions, the harrows come up the same ridge and finish it, the double tine up-hill being easy because of the ground having been passed over by the harrowing down-hill; and so on with every succeeding ridge.

As there is little room for two pair of harrows to turn at the end of one and the same ridge, the leading harrows are driven forward upon the head-ridge, and the horses are *hied* so as to move round upon the far side of the head-ridge, and still *hied* round, they take up their place on the same side of the ridge they had come down; while the hind harrows are *hupped* so far on the head-ridge as to turn on its far side, and then *hieing*, take up their position on the same side of the ridge they had come down, in rear of the leading harrows.

But where four pairs of horses are at work—and four pairs are required to cover in and finish as fast as the broadcast sower deposits the seed—this plan would be apt to lead to confusion. If the field ascends from the gate, each pair of harrows may go up a separate open furrow, as these require more harrowing than the other portions; and when the top of the field is reached, all the pairs go down the side of the field where the sower has commenced. At the bottom, the first pair of harrows pass along the head-ridge to the left in front of the second pair, which pass to the right, the one pair going up the land upon which the other came down. The third and fourth pairs do likewise, and in this way confusion in turning is avoided.

The entire movements are easily and quickly managed with double reins; but with a single rein, even with the voice, this mode of turning at the end of a ridge is apt to create confusion.

If the incline is begun to be sown at the opposite side of the field, the same arrangements as have just been described for easy breaking-in of the seed for the horses, whether from foot or top of the incline, should be followed; but in following them here the horses should be *hupped*—turned to the right—instead of

hied, because the open side of the field is on a different hand.

When the field is *level*, it matters not from which side the breaking-in commences.

Cross-harrowing.—After the appointed piece of ground, whether a whole field or part, has been sown and broken-in, the land is *cross-harrowed* a double tine—that is, at right angles to the former harrowing, and to the ridges. But as, for this operation, the ground is not confined within the breadth of ridges, the harrows cover the ground with their whole breadth, and get over the work in less time than in breaking-in.

Cross-harrowing is not easy for the horses, inasmuch as the stripes left in the ground by the breaking-in have to be cut through, and the irregular motion of the harrows, in jerking across the open furrows of the ridges, has a fatiguing effect upon the horses.

To finish the harrowing, another double tine along the ridges, as in the case of the breaking-in, may be necessary. This turn is easily and quickly performed, the soil having been so often moved; and should it seem uniform in texture, a single tine will suffice for a good finishing.

Efficient Harrowing.—To judge of the harrowing of land, the sense of feeling is required as well as that of sight. When well done, the soil seems uniformly smooth, and the small clods lie loosely upon the surface; the ground feeling uniformly consistent under the tread of the foot. When not sufficiently harrowed, the surface appears rough, the clods are half hid in the soil, and the ground feels unequal under the foot—in some parts resisting its pressure, in others giving way to it too easily.

The old saying that "good harrowing is half farming" has more wisdom in it than at first sight appears. The *efficient harrowing* of land is of more importance than seems generally to be imagined. Its object is not merely to cover the seeds, but to pulverise the ground, and render it of a uniform texture. Uniformity of texture maintains in the soil a more equable temperature, not absorbing rain so fast, or admitting drought too easily, as is the case when the soil is rough and kept open by clods.

Whenever the texture becomes sufficiently fine and uniform, the harrowing should cease, although the appointed number of double or single tines have not been given; for it is a fact, especially in light, soft soils, that over-harrowing brings part of the seed up again to the surface.

Water-furrows.—When the spring wheat was sown early in the season, in January or near the end of February, it was usually considered necessary in former times that the ridges should be *water-furrowed*, so that, in case of much rain falling, or snow melting, it may run off the surface of the ground by the water-furrows. Whatever of the spring wheat is sown late in the spring, in the last of February and beginning of March, the water-furrowing is not executed until after the sowing of the grass-seeds, if any are to be sown with the wheat crop.

Water-furrowing is making a slight plough-furrow in every open furrow, as a channel for rain-water to flow off the land. It may be executed lightly with a common plough and one horse, but better with a double mould-board plough and one horse; and as the single horse walks in the open furrow, the plough following obliterates his footmarks.

The better water-furrowing by the double mould-board plough consists in the channel having equal sides; and the furrow-slice on each side being small, compared with the one furrow-slice of the common plough on one side, the water can run more freely into the furrow. The plough simply goes up one open furrow and down another until the field is finished, the horse being *hied* at the turns into the open furrow. Water-furrowing finishes the work of the field.

Under-drainage *v.* **Water-furrows.**—On average soils there will be no necessity for water-furrows if the land is thoroughly under-drained. The importance of this latter is now universally acknowledged, and great benefit has been derived by the large extent to which drainage has been executed throughout the country. When the soil is exceptionally adhesive, and water apt to lie in pools on its surface, it is very desirable that water-furrows should be provided to prevent this.

Wheat after Grass.—The foregoing relates mainly to the sowing of wheat

after a root crop. But a large extent of spring wheat is also sown after grass, chiefly in England, and some of the earlier and drier districts of Scotland. The success of spring wheat after grass in England attests the superiority of the English climate, which is too dry, and too warm in the southern counties, for the perfect growth of oats. A great obstacle to sowing wheat in Scotland in spring is the action of two classes of soil on the growth of that plant. Clay soils are too inert in the average climate of Scotland to mature the growth of wheat in a few months; and the light soils, though more favourable to quick vegetation, want stamina to support the wheat plant, and are, besides, too easily affected by drought in early spring—it being no uncommon occurrence in Scotland to experience a severe drought in March, and during the prevailing east wind.

Wheat cannot be safely sown in the autumn in Scotland after the end of October, which is the time for sowing after potatoes. Some sow it in November, to the risk of producing a thin crop. To plough up lea before October would be to sacrifice the aftermath. Many farmers do this without hesitation, rather than lose the advantage of sowing wheat in good time before the winter sets in. But with others the aftermath is of greater importance, and they accordingly defer the ploughing of the lea till winter, and the sowing of the wheat till spring. January is considered a good month for wheat-sowing, but it is only in exceptional seasons and in favoured districts that the weather permits of this. There is thus a considerable extent of spring wheat sown after grass.

Presser-roller.—This implement was called into use with the object of consolidating light soils, so as they might withstand the drought of spring and support the wheat plant until it attains maturity. The action of the presser-roller is to consolidate the soil in the lineal spaces in which the seeds of wheat are to have root; hence it is applicable only in drill culture on loose soil, whether after lea or on bare land.

The presser-roller is in perspective represented in fig. 269, and fig. 270 gives edge-view of the two pressing-wheels detached from the carriage, in which is the axle of the two pressing-wheels as they appear edgewise, their weight being about 2 cwt. each. The pressing-wheels

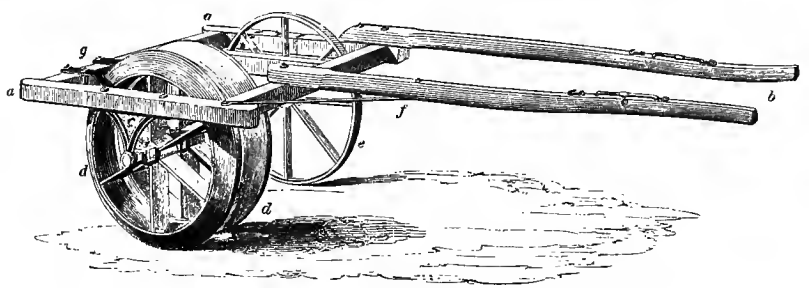


Fig. 269.—*Presser-roller.*

a a Rectangular frame.
b Pair of shafts.
c Cast-iron bracket.
d d Two pressing wheels.
e Light carriage-wheel.
f Iron stay-rod.
g Two iron scrapers.

are held at the required distance by square collars. A transverse section of the ground undergoing the pressing process is the shaded part of the section, exhibiting the state of a soft soil when pressed by the roller; and the dotted lines of the newly-ploughed furrow-slices of lea undergoing consolidation. With reference again to fig. 270, the pressing-wheels are to be understood as running always upon the last-turned-up furrows but one; while the light carriage-wheel runs always upon the solid land, where the horse also walks, the shafts being placed at that side.

But the presser is now being more advantageously used as to *time*, in the consolidation of soft soils, by being constructed with 4, 6, or more pressing-wheels; and in this form the carriage-

wheel is not required. In using the pressure of this construction, the field must be ploughed for the seed-furrow, either entirely or in part, before the pressing is begun; and the field is regularly gone over by the presser, which, from its now increased weight, will require two horses. In this form, with 6 pressing-wheels and with 2 horses, the

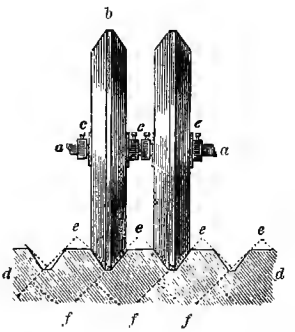


Fig. 270.—*Action of the edge of presser-wheels.*

a a Axle.
b b Two pressing-wheels.
c c c Square collars upon the axle.
d d Transverse section of ground being pressed.
e f Newly ploughed lea, furrow-slices in dotted lines.

machine will press-roll from 8 to 9 acres in a day. The entire weight of the 6-wheel rollers amounts to about 12 or 13 cwt. The work done by them is very efficient.

Use of the Land-presser.—The land-presser is not now used so extensively as it was formerly. This is to be regretted, for there can be no doubt of its beneficial influence upon light soils liable to suffer from drought in spring. The presser may also be beneficially employed in compressing light turnip-land when ploughing into ridges, to render it more fit for spring wheat; and in using it for this purpose it might be employed in the same manner as on lea. The late Hugh Watson Keillor, Forfarshire, stated that, having used the land-presser, he could "with confidence recommend it *on all light soils with every sort of corn crop.*"[1] The late Mr A. Bowie, Mains of Kelly, Forfarshire, remarked: "The presser is a most useful implement for easy dry soils. For saving seed and growing heavy crops it is a powerful auxiliary to the farmer of such soils; perhaps it is equal, if not superior, to the drill in these respects."

Spring Varieties of Wheat.—As to the varieties of wheat which should be sown in spring in different localities, it would be imprudent to dogmatise. With the great attention now being given to the improvement of farm plants, and to the bringing out of new varieties and stocks of exceptional vigour and power of production, it is quite probable that the variety which is considered best to-day will be excelled in the near future. Farmers must therefore be constantly on the outlook for improved sorts, and be guided by the experience of the time as to which variety they should select.

It is this same consideration — the great ingenuity and enterprise employed in developing new sorts, and the rapidity with which one good sort is supplanted by a still better—which influenced us in deciding not to attempt in this work a detailed description of the different varieties or sorts of the respective farm crops now in use in this country.

For guidance as to the best varieties to use, no farmer need have any difficulty. By a careful study of the experience of other farmers, and due consideration of his own peculiar conditions as to soil and climate, he is not likely to be far wrong as to the selection of varieties.

Of course care must be taken not to sow a *distinctly winter* variety of wheat in spring. As to a winter wheat no mistake can be made, for however early may be the habit of the variety sown, the very circumstance of its being sown in autumn, when sufficient time is not given to the plant to reach maturity before winter, will convert it for that season into a winter variety. The wheat plant is a true annual, but when sown late, and the progress of its growth is retarded by a depression of temperature, it is converted for the time into a biennial. It is therefore highly probable that, as the nature of wheat is to bring its seed to maturity in the course of one season, any variety sown in time in spring would mature its seed in the course of the ensuing summer or autumn. This is believed to be a fact; nevertheless, circumstances may occur to modify the fact *in this climate.* Under the most favourable cir-

[1] *Jour. Agric.*, iv. 545.

cumstances, the wheat plant requires a considerable time to mature its seed; and a variety that has long been cultivated in winter, on being sown in spring in the same latitude, will not mature its seed that season should the temperature fall much below the average, or should it be cultivated on very inferior soil to that to which it had been accustomed. In practice, therefore, it is not safe—at least in so precarious a climate as that of Scotland—to sow *every variety* of wheat in spring.

Spring Wheat-seed from Early Districts.—Wheat taken from a warm to a cold climate will prove earlier there than the native varieties, and, in so far, better suited for sowing in spring; and if the same variety is an early one in the warm latitude—bringing its seed to maturity in a short period, perhaps not exceeding 4 months—then it may safely be sown as a spring wheat, whether it be red or white, bearded or beardless.

The long experience of the late Mr Patrick Sheriff, East Lothian, led him to the conclusion that autumn wheats should not be sown in spring, as they will not produce a sufficient number of prolific ears.

Late Varieties of Wheat.—Special attention has been given in recent years to the bringing out of varieties of wheat suitable for sowing late in spring. Considerable success has been attained, and there are varieties now in use which in average years give fairly satisfactory results, although not sown till March or April.

Manuring Wheat.—In the description of the Rothamsted experiments in pages 135-169 of this volume, much useful and suggestive information as to the manuring of wheat will be found. Wheat is usually sown on land in good heart, for the most part after a potato or root crop, with which a heavy dressing of dung and artificial manure had been applied. In this case no special application of manure may be necessary for the wheat beyond perhaps a top-dressing with a little ammonia salts or nitrate of soda in spring. The sulphate of ammonia may be sown at the same time as the seed for the spring wheat, or early in spring for winter wheat, but nitrate of soda should not be sown until the plants are able to immediately assimilate the manure. From 1 to 2 cwt. per acre are common quantities of these fertilisers for top-dressing wheat.

When the land has not been liberally manured with the preceding crop, a heavier dressing, including phosphatic and potassic manures, must be given to the wheat crop; or it may be manured with dung. See chapter on "Manures and Manuring."

SOWING BEANS.

Beans take about 7 months to come to maturity, and should therefore be sown early—as early in spring as possible. They should be sown in February if the weather and the condition of the land permit; in no case later than March. A very favourable season may hasten the plant through its courses of vegetation in a shorter time; but a very unfavourable season will so retard it as almost to prevent the formation of the seed.

In Scotland the bean is not a reliable crop. It was never cultivated extensively there, and in recent years has lost ground slightly. Strong land is best suited for beans, and it still holds an important place on good carse farms. The land must be in good heart, and is generally well manured with dung in the previous autumn or winter. Beans are sown on the flat surface, or in rows from 15 to 20 inches apart, or in raised drills from 25 to 30 inches wide. The bean crop occupies varying positions in the rotation. It usually comes in between two cereal crops, between two crops of wheat, between oats and wheat, or between wheat and barley.

The bean crop is valuable both for its straw and grain. Though the crop fail in seed, it seldom fails to produce good fodder provided it can be well secured. A dry season stints the growth of the haulm, but produces beans of fine quality; and a wet season prevents the growth of the bean, but affords a bulky crop of fodder.

The *culture* for beans is not dependent so much on the soil as on the peculiar growth of the plant. Bearing fruit-pods on its stem near the ground as well as near the top, it should have both light

and air; and its leaves being at the top, and its stem comparatively bare, weeds find room to grow. The plant should therefore be wide asunder in the row and between the rows, so that the crop may become luxuriant and the land cleaned.

Beans were long wont to be sown *broadcast*, and are so sown still in some cases. It is not a good plan, however, for it has a great tendency to leave the land full of weeds.

Varieties of Beans.—Several varieties are in cultivation. Those most largely sown are the common Scotch or horse bean, and the common tick-bean. The former is the best suited for northern districts, and under favourable circumstances grows to a height of 4 or 5 feet, weighing from 62 to 65 lb. per bushel. The seed is large, flat, of a dingy whitish colour, with a black eye, and irregularly wrinkled on the sides. The tick-bean, which is shorter in the straw, and generally more prolific, is the variety most largely cultivated in England. The seed is smaller, plumper, a pound or two heavier per bushel than the seed of the horse-bean. Amongst the other best-known varieties are the Russian or winter bean, the Mazagan, and the Heligoland bean.

Quantity of Seed.—From three to four bushels per acre are the most general quantities. In the north it is more frequently four than three, sometimes even five bushels. The seed is sown by machines of various patterns—sort of barrow-shaped appliances, worked by hand or horse power, and sowing usually one or three drills or rows at a time.

Manure for Beans.—Land intended for beans is usually well dunged in the autumn, or early in winter, with perhaps from 8 to 12 tons of farmyard dung, spread just before the land is ploughed. The dung will be all the better for this purpose if it is tolerably fresh, and it should be spread evenly on the land. In other cases, the dung is spread early in spring on the flat or in drills, as for turnips. When the dung is to be spread in drills, these are opened a little deeper than if the land were simply drilled to receive the seed.

Formerly it was thought that beans could not be grown satisfactorily without farmyard dung, but, as shown clearly by the Highland and Agricultural Society's experiments, that idea was not well founded. The artificial manures which gave the best results in these experiments are described by Dr Aitken on p. 182. Potash is the dominant ingredient. It is seen that, unaccompanied by potash, neither phosphates nor nitrate is of much use to the bean, whether applied separately or together; but the addition of potash to either or both, at once enormously increases the crop. The artificial manures were applied in March, three days before the seed was drilled in with the three-drill bean-barrow.

Beans and Nitrogenous Manure.—Seeing that a leguminous crop such as beans contains a great deal more nitrogen than cereal crops, it might be expected that nitrogenous manures would exercise a more beneficial effect upon beans than upon cereals. It has been found, however, that such is not the case. At Rothamsted extensive experiments have been carried out in the manuring of beans and other leguminous crops, but curiously enough the results have not been so clear or instructive as those obtained from the manuring experiments with most other crops. Sir J. B. Lawes says:—

"The general result of the experiments with beans has been, that mineral constituents used as manure (more particularly potash) increased the produce very much during the early years; and to a certain extent afterwards, whenever the season was favourable for the crop. Ammonia salts, on the other hand, produced very little effect; notwithstanding that a leguminous crop contains two, three, or more times as much nitrogen as a cereal one grown under similar conditions as to soil, &c. Nitrate of soda has, however, produced more marked effects. But when the same description of leguminous crop is grown too frequently on the same land it seems to be peculiarly subject to disease, which no conditions of manuring that we have hitherto tried seem to obviate.

"Experiments with peas were soon abandoned, owing to the difficulty of keeping the land free from weeds, and an alternation of beans and wheat was substituted; the beans being manured much as in the experiments with the same crop grown continuously.

"In alternating wheat with beans, the remarkable result was obtained, that nearly as much wheat, and nearly as much nitrogen, were yielded in eight crops of wheat in alternation with the highly nitrogenous beans, as in sixteen crops of wheat grown consecutively without manure in another field, and also nearly as much as were obtained in a third field in eight crops alternated with bare fallow."

Ploughing for Beans.—Strong land intended for beans is usually ploughed about the end of autumn or early in winter, so that it may have the benefit of the pulverising influences of winter. If the land is very heavy and liable to hold surface water, it will be useful to plough it in the direction of the greatest inclination or fall, so that there may be no cross-furrows to retain the water. But when the land can be ploughed across the inclination it will be well to do so, and then the drills, if the crop is to be grown in drills, will follow the inclination, thus crossing the autumn furrow.

Spring Tillage for Beans.—The amount and kind of tillage which bean land should receive in spring will depend upon the nature and condition of land, and the character of the season. If the land lying in the winter furrow is tolerably friable, harrowing may be sufficient. As a rule, however, a turn of the grubber or cultivator will be found beneficial.

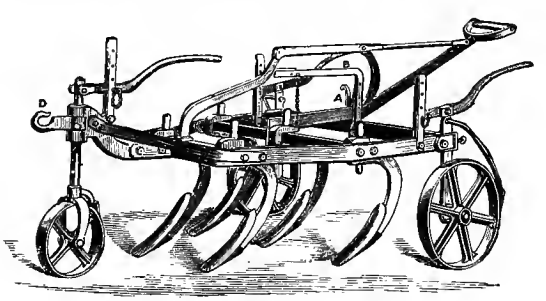


Fig. 271.—*Clay's cultivator.*

The improved grubbers or cultivators are excellent implements for pulverising surface soil. They do their work well, and are very speedy—a consideration of special importance at this time of the year.

Fig. 271 represents Clay's well-known

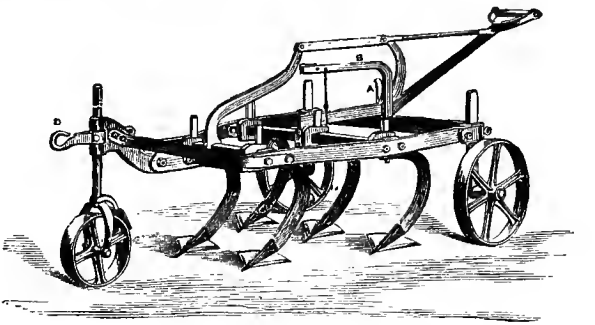


Fig. 272.—*Broadshare cultivator.*

cultivator, while in fig. 272 the same implement is fitted as a broadshare cultivator. Other forms of grubbers will be referred to in dealing with tillage for root crops.

The action of the grubber or cultivator in the soil is to stir it effectually as deep as the tines descend, and at the same time retain the surface-soil in its existing position. This advantage is especially appreciated in early spring, when it is precarious to turn over the soil with the plough, lest by a fresh fall of rain it should become wetter and worse to work than if it had not been ploughed at all. If the land be raw and not very clean, and the weather precarious, the grubber will prepare the soil for harrowing, of which it should receive one double tine along the ridges, the grubbing having been given across them. Should this not be sufficient to reduce the clod, another double tine should be given across the ridges, when the land will be ready for sowing.

If the weather in spring is favourable, and the beans are to be sown broadcast or in rows on the flat, ploughing across the winter furrow is by many considered desirable. The modern grubbers or cultivators, however, do their work so well

that the necessity for the plough in spring is much lessened.

In preparing land in spring for beans, care should be taken not to grub or harrow more in one day than can be drilled up or sown on the same or the following. A fall of rain on this prepared ground before it is drilled for the seed would be detrimental to the crop.

Sowing Autumn-manured Beans.—The process of sowing beans upon land which had been purposely dunged and ploughed in autumn or early winter, is thus described by Mr F. Muirhead:—

"We will suppose the time has arrived for sowing the seed. The young farmer should previously have had his bean-sowing machine examined, repaired if necessary, and well oiled. He should also have provided the requisite quantity of seed—say 4 bushels of common Scotch beans for every imperial acre, and he had better have an extra bag of beans for every twenty he intends to sow, in case he may need a little more to finish the field than he anticipated,

"He should visit the field a day beforehand, and ascertain the length of the proposed drills, and how many make an imperial acre; and the following table may assist him:—

Inches wide.	Yards long.
Drills.	Imperial acre.
26	6701
27	6453
28	6222

"The open furrows should be filled in with two or three bouts of a two-horse plough, and the ends or headlands marked off, say, to hold eight drills, which should be ample room to admit of horses and ploughs turning quickly without treading on the newly formed drills. If the land requires a double stroke of heavy harrows before being drilled, as much should be harrowed the afternoon previous to sowing (provided weather is somewhat settled) as to allow the ploughs to get to work *readily* the following morning, or the foreman had better be sent half a day beforehand to do this, and to open, say, ten or twelve drills; and care should be taken, if the field has much inclination from top to bottom, to begin at that side of it which will, in covering up the sown seeds, give the horses the heavy furrow *down* hill. The following morning fully as much seed is taken out to the field as will likely be needed during the forenoon, and the bags should be placed along the top headland, if drills are not too long to admit of the three-drill horse sowing-machine sowing a 'bout' or six drills before it needed to be refilled, care being taken that the seed always covered the pinions for forcing out the beans.

"In placing the bags with the seed, suppose that it takes thirty drills to be an acre imperial, and we wish to sow 18 stones per acre, it will be more convenient to have the beans weighed up to that weight in each bag, and place the bags along the headland, one bag at the last drill of each acre; and in beginning to sow, it will be found of advantage to take out as much extra seed in a bag as cover the pinions of the sowing-machine, so that when the *first* bag is all sown, the person in charge knows at once whether the machine is sowing too quickly or too thinly. Perhaps if the first bag were accurately divided into two, and set down separately, at half an acre for each, the setting of the machine would be the sooner tested. The sowing-machine will now begin and sow the three outside drills, and the ploughs will commence and cover up the seed as they go *down hill*, and open fresh drills at the required width as they return. One sowing-machine will easily keep four or five pairs of horses at work."[1]

Sowing Spring-manured Beans.—When the dung has to be applied to the *drills* in spring, it is carted to the field, and thrown in graipfuls as the horse moves along the drills, just as in the dunging of roots or potatoes. The graipfuls are then spread evenly along the bottom of the drills, which, having received the seed, are thereupon closed.

If the dung has to be applied in spring, and it is intended to sow the beans *broadcast* or *in rows* on the flat, then the land receives a single or double turn of the harrow, the dung is spread evenly on the surface, and the land ploughed, the seed, perhaps, being dropped by the single bean-barrow into every third drill. And as the furrows are about 9 inches in

[1] *Farming World Almanac*, 1888.

breadth, the three furrows will place the rows of beans at 27 inches apart. This ploughing finishes the operation.

When the land is manured in the spring, and the seed sown broadcast, the dung in the same state is spread broadcast upon the surface. The further part of the operation depends on the state of the weather. Should it promise well until the bean-sowing is finished, the dung may be ploughed in, the seed sown broadcast upon the ploughed surface, harrowed in with a double tine, and the ridges water-furrowed. Should the weather seem doubtful, a safer plan is to sow the seed broadcast upon the spread dung, and plough in both seed and dung together, and the surface will be secured from danger. In this case the plants will come up in rows of the breadth of the furrow—9 inches apart.

Harrowing Drills.—If it is considered desirable to harrow the drills, this may be done about a fortnight after the sowing, if the surface is at all dry. If the land is wet, the harrowing should be delayed, and the first dry state of the surface taken advantage of. The common harrow is sometimes used to harrow down drills; but a better implement is the *saddle drill-harrow*, such as represented in fig. 273, made by C. Clay &

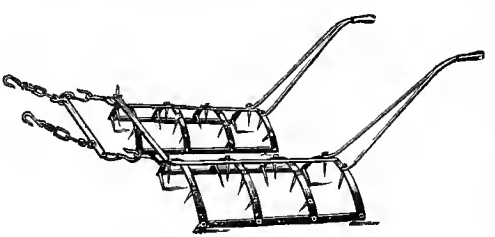


Fig. 273.—*Saddle drill-harrow.*

Co., Wakefield. This harrow is worked in pairs; and, to render it applicable to its purpose, it is made of an arch form, partially embracing the curvature of the drill, and on this account is best fabricated of iron. The pair of harrows are drawn by one horse, walking between the drills.

Beans and Peas Mixed.—Beans and peas are often grown together, the seed being sown broadcast. The most general proportion is about one-third of peas to two-thirds of beans.

Botanical Character of Beans.—It was an observation of De Candolle, that "it is remarkable that the botanical character of the *Leguminosæ* should so strictly agree with the properties of their seed. The latter may be divided into two sections—namely, the first, *Sarcolobæ*, or those of which the cotyledons are thick, and filled with fecula, and destitute of cortical pores, and which, moreover, in germination do not undergo any change, but nourish the young plant by means of that supply of food which they already contain; second, the *Phyllolobæ*, or those of which the cotyledons are thin, with very little fecula, and furnished with cortical pores, which change at once into leaves at the time of germination, for the purpose of elaborating food for the young plant. All the seeds of the *sarcolobæ* are used as food in different countries, and none of those of *phyllolobæ* are ever so employed."

Ancient Notions regarding Beans.—The ancient Greeks had some strange notions regarding the bean. Thus Didymus the Alexandrian says: "Do not plant beans near the roots of a tree, lest the tree be dried. That they may boil well, sprinkle water with nitre over them. Physicians, indeed, say that beans make the persons that eat them heavy; they also think that they prevent night dreams, for they are flatulent. They likewise say that domestic fowls that always eat them become barren. Pythagoras also says that you must not eat beans, because there are found in the flour of the plant inauspicious letters. They also say that a bean that has been eroded becomes whole again at the increase of the moon: that it will by no means be boiled in salt water, nor, consequently, in sea-water," &c.[1]

SOWING PEAS.

Peas are sown to a smaller extent than they were at one time in this country. They seldom take a prominent place as an ordinary rotation crop, but are largely

[1] Owen's *Geoponika*, i. 82.

grown near populous towns for sale in the green pod.

Peas give the best results on light and friable loamy soils of a calcareous character, or which had been recently dressed with lime or chalk. It is a general observation, that annual weeds are encouraged in growth amongst peas; and the pea being a precarious crop, yielding a small return of grain, except in fine warm seasons, a mere good crop of straw is insufficient remuneration for a scanty crop of grain, accompanied with a foul state of land. Hence in many cases turnips have been substituted for peas.

Peas, for a long period, were invariably sown broadcast; but seeing their tendency to protect weeds, and that drill-culture rendered the land clean, the conclusion was obvious that peas sown in drills would admit of the land being cleansed. It was found that the straw by its rapid growth creeping along the ground soon prevents the use of the weeding instruments. To counteract this tendency, the practice was introduced of sowing peas and beans together, and while their seasons of growth coincide, the stems of the bean serve as stakes to support the bines of the pea. The proportion of pea to bean when mixed usually is as 1 to 3.

Tillage for Peas.—It is somehow considered of little moment how the land shall be ploughed, when the pea is to be sown by itself. Sometimes only one furrow after the stubble is given; and when the land is tender and pretty clean, a sufficient tilth may be raised in this manner to cover the seed, which requires neither a deep soil for its roots (which are fibrous and spreading near the surface), nor a deep covering of earth above them, 2 inches sufficing for the purpose. But a single furrow does not do justice to the land, whatever it may do for the crop. The land should be double drilled or grubbed after the spring ploughing.

Since the pea can be cultivated along with the bean, it will grow on good strong soils; and its spreading roots enable it to grow on thin clays, where the bean does not thrive. But as corn, the pea, as has been indicated, thrives best on light soils. In clay, it produces a large bulk of straw, and the grain depends on the season being dry and warm; and as this is not the usual character of our climate, the yield is but indifferent.

Dung is seldom given to the pea when sown by itself, having the effect of forcing much straw with little grain.

When peas and beans are reaped together, they are separated when thrashed simply by riddling, the peas passing through the meshes of the riddle, while the beans are left upon the riddle.

Sowing Peas. — Peas are sown by hand when cultivated broadcast, and with the barrow when in rows, in every third, or in every furrow. With beans, they are sown by a barrow; on drilled land, broadcast by the hand: the seed falling to the bottom of the drills is covered by the harrows passing across the drills. Like beans, peas are sown on ploughed lea in some parts of England. On lea, the pea is dibbled in the harrowed surface, the holes being placed about 9 inches asunder. When varieties of the white garden-pea are cultivated in the field, as in the southern counties of England, these various modes of sowing them deserve attention; as also in the neighbourhood of large towns, where the garden-pea is cultivated and sent in a green state to the vegetable market.

The quantity of seed per acre varies, in drilling, from 2½ to 3 bushels per acre in the south, and sometimes as much as 4 in the north. The rows are usually from 12 to 15 inches apart. A little more seed is used in sowing broadcast.

The *varieties* of peas are very numerous. Of the varieties of the field-pea, the partridge grey pea in fig. 231, p. 497, vol. i., is suited to light soils and late situations, and is considered of excellent quality, and prolific when the crop is full.

TRANSPLANTING TURNIP BULBS FOR SEED.

When a farmer gets possession of a first-class variety of turnip, which he finds well suited to his land, he should grow from it every year at least as much seed as will supply his own wants—perhaps even a quantity for sale. The seed should be grown from well-formed bulbs, transplanted, perhaps early in March, just before spring growth begins to show itself. With intelligent care, and good

varieties of roots, the seed may be grown successfully.

The extent of ground required is not great. Reckoning the crop of seed at 30 bushels per acre, weighing 50 lb. per bushel, and allowing 3 lb. per acre of seed for the turnip crop, 10 square yards of ground will supply the seed for every acre of turnips grown on the farm. It is necessary to have the plants of different sorts of turnips at a considerable distance from each other; because, if near, one variety will be impregnated by another, by bees and other insects carrying the pollen of one flower to another.

Let a piece of ground be selected for each variety of seed to be raised. Spare spaces in the corners of fields may be converted into nurseries for the purpose. Let the ground receive a little dung; and the easiest mode of making friable mould at once upon such places is trenching with the spade, and removing stones and weeds. Then select the best-formed bulbs of the different kinds from the fields as they are growing; take them up carefully, preserving the roots and fibres entire, and cutting off the shaws nearly close to the bulb.

A line of trench is made in the ground, deep enough to contain easily the bulbs and roots, which are inserted at 12 inches apart, and leaving the tops only above the ground, when the earth is returned into the trench. The rows of transplanted bulbs should be 3 feet asunder, to allow air to the plants, and afford room for a person to pass between them to watch the seed, when it is near ripe, from the depredation of small birds. In rows wide apart the plants become stronger and more prolific.

The best time of transplanting turnips is about the beginning of March, before any symptoms of spring growth appear. In a large piece of ground the plough can form the trenches, and harrows reduce the ground into mould.

The ground occupied for raising turnip-seed should be protected by a fence of hurdles against stock, otherwise the crop may suffer.

Birds often play havoc with turnip-seed as it approaches maturity. Unless some means are employed to scare off the birds, they may indeed destroy almost the entire crop. Boys are often told off to this duty, others throw old fisher nets over the seed, and this latter is the most effective method of prevention.

SOWING BARLEY.

It may be laid down as an axiom that the seed-bed upon which barley is to be sown should be fine, moderately deep, and clean, with an abundant supply of all the ingredients necessary for the growth of the plant present in a soluble or readily available form. Land after turnips is the place in the rotation which is generally set aside for the growth of barley.

Tillage for Barley.—If the land is not of the heavy order of soils, all that is necessary is the ordinary ploughing, especially if it can be accomplished by the second week of February. The action of the weather and frost will break down and mellow the soil, rendering it friable, so that a double tine of the harrows before putting in the seed is all that is needed to obtain a seed-bed in good tilth. On the heavier class of soils, and where ploughing cannot be done until later, more especially where the turnip crop has been eaten off by sheep, two ploughings may be necessary as well as harrowing before seeding.

But the simplest and easiest mode of procedure is to plough the land with one of the new Anglo-American ploughs, which will break down the furrow, leave the land level, and in excellent tilth. By this plan the old method of cross-ploughing, scarifying, grubbing, ribbing, &c., may be obviated.

It is probable that some of the turnip-land which may have been ploughed for spring wheat may have to be sown with barley, on account of inclement weather preventing the sowing of wheat in seasonable time. In that case, whether the land had been gathered up from the flat, or cast together, it should be seed-furrowed in the same form for the barley, to retain the uniform ridging of the field; for the ploughing for spring wheat being the seed-furrow, and the ridges made permanent, it would be impossible to reverse the ploughing with one furrow, without leaving one ridge on each side of the field half the width of the rest.

The ridges would have to be ploughed *twice* to bring them back to their proper form, but for which there could not be time, so they must be stirred with the grubber, or ribbed with the small plough.

Another method which is being adopted by farmers is to plough the land after turnips, in breaks of six ridges, gathering four and splitting two. This has become advisable nowadays, owing to the advent of the reaper, for which the old open furrows were very unhandy, while the crop was uneven, as the growth on the crown of the ridge was heavier than that in the furrow which divided the ridges.

If the ridges have consolidated on being long ploughed, the grubber will make a suitable bed for the barley seed, and keep the dry surface uppermost. If the soil is dry and loose on the surface, and tilly below, it will be best preserved by ribbing with the small plough.

A capital implement for preparing a fine seed-bed is the "Acme harrow," illustrated in fig. 274, an ingenious

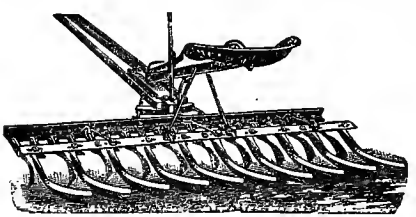


Fig. 274.—*Acme harrow.*

American invention, and brought to this country by Lankester & Co., London. It breaks up and pulverises the surface soil most thoroughly.

By putting such ridges thus into the best state for barley, there will be no difficulty in ploughing the rest of the land. The first furrow upon the trampled soil should be the *cross*-furrow.

Although the field may not be cleared of turnips to allow cross-ploughing from side to side, any portion should be ploughed, and, after harrowing the cross-ploughed land a double tine along, it should be gathered up from the flat, or yoked together; and both the cross and ridging-up furrows should be *deep*. The cross-ploughing should be turned over with a broad furrow-slice, but the ridging-up should be done with a deep narrow furrow-slice, to subdivide and pulverise the soil.

Sowing.—Sowing barley upon a fine evenly pulverised surface requires strict attention, inasmuch as on whatever spot every seed falls, there it lies, the soft earth having no elasticity to make the seed rebound and settle on another spot. Hence, of all sorts of corn, barley is the most likely to be striped in sowing by hand, so every handful must be cast with great force. Walking on soft ground in sowing barley is attended with considerable fatigue. Short steps are best suited for walking upon soft ground, and small handfuls are best for grasping plump slippery barley.

The broadcast machine sows barley as well as oats on the ploughed surface, and so do the corn-drills across the ridges after the surface has been harrowed. The grubbed surface is best sown by a drill-machine, affording the seed a firm hold of the ground, while the surface ribbed with the small plough is best sown by hand, or with the broadcast machine, the seeds falling into the ribs, from which the young plants rise in rows, the ground being harrowed only a double tine along the ribs. Barley may be sown any time fit for spring wheat, and as late as the month of May. But the earlier crop will be of better quality and more uniform, though the straw may be shorter.

Quantity of Seed.—The quantity of seed sown broadcast is from 2½ to 4 bushels to the acre. When sown early, less suffices; when late, more is required, because less time is given to tiller and cover the ground. Sown with the drill, 2 bushels suffice.

Brown makes some sensible remarks on this subject. "Amongst the farmers," he says, "it seems a disputed point, whether the practice of giving so small a quantity of seed (3 bushels per acre) to the best lands is advantageous. That there is a saving of grain, there can be no doubt; and that the bulk may be as great as if more seed had been sown, there can be as little question. Little argument, however, is necessary to prove that thin sowing of barley must be attended with considerable disadvantage; for if the early part of the season be dry, the plants will not only be stinted in their growth, but will not send out offsets; and

if rain afterwards falls—an occurrence that must take place some time during the summer, often at a late period of it—the plants *then begin to stool*, and send out a number of young shoots. These young shoots, unless under very favourable circumstances, cannot be expected to arrive at maturity; or if their ripening is waited for, there will be great risk of losing the early part of the crop—a circumstance that frequently happens. In almost every instance an unequal sample is produced, and the grain is for the most part of inferior quality. By good judges it is thought preferable to sow a quantity of seed sufficient to ensure a full crop without depending on its sending out offsets. Indeed, when that is done, few offsets are produced—the crop grows and ripens equally, and the grain is uniformly good."[1]

Germination of Barley and the Weather.—No grain is so much affected by weather at seed-time as barley. A dash of rain on strong land is liable to cause the crop to be thin, many of the seeds not germinating, whilst others burst. In moist, warm weather, the germination is certain and very rapid; and it has been observed, that unless barley germinate quickly, the crop will be thin. We have seen the germ of barley pierce the ground only 36 hours after it had been sown, when the ground was smoking by evaporation of moisture, caused by a hot sun in a close atmosphere. We have also traced the germ of barley to its root to the depth of 9 inches below the surface; and this shows that land should be ploughed to a moderate depth for barley.

Harrowing for Barley.—The harrowing required for barley land sown broadcast is generally less than for oat land, a double tine being given in breaking-in the seed, and a double tine across immediately after. When sown with the drill-machine, the harrowing is perhaps a double tine along, and double tine across the ridges, before the seed is sown. When sown on ribbed land, the only harrowing may be a double tine along the ribs, just to cover the seed, as the ribs afford it a sufficient hold of the ground. Care, however, should be taken in all cases to ensure a fine even seed-bed for barley. The condition of the land will be the best guide as to the amount of harrowing required in individual cases.

The head-ridges are ploughed and sown by themselves.

Finishing.—The grass seeds are then sown with the grass-seed sowing-machine; the land harrowed a single tine with the light grass-seed harrows, and thereupon finished by immediate rolling. On strong land, apt to be incrusted on the surface by drought after rain, rolling may *precede the sowing of grass seeds*, and the work is finished with the grass-seed harrows, and perhaps another turn of the roller. On all kindly soils, rolling last is best for keeping out drought, and giving a smooth surface for harvest-work.

Soil for Barley.—Medium and light loams of a calcareous and friable nature—such as are generally known as good turnip lands—are best adapted to barley.

Barley is grown most largely after turnips, and is especially suited for following where a portion of the roots has been consumed on the land by sheep. In some cases it is sown after potatoes or beans, especially if the land and the season are unfavourable for wheat. When intended for barley, the potato or bean land is gathered up for the winter, water-furrowed, and gaw-cut; and in spring it may be grubbed or cross-ploughed and ridged up for the seed-furrow.

Barley is sown also after wheat, and the sample is always fine-coloured. Barley is never sown in Scotland after lea, but might be if the land were partially fallowed in spring. Barley does not stand the winter in Scotland as it does in the warm calcareous soils of the south of England. Winter barley is early ripe, and prolific; but if the weather causes it to tiller in spring, it produces an unequal sample, containing a large proportion of light grain.

Varieties of Barley.—The varieties of barley are numerous. They are generally distinguished by the number of rows of grain which grow upon the ear. The kind which is cultivated in this country to the greatest extent is two-rowed or long-eared, from which many improved varieties have sprung, notably the "Chevalier," "Annat," "Dunlop," &c.

The *Chevalier* variety was propagated by a Mr Chevalier, who, when examin-

[1] Brown's *Rur. Aff.*, ii. 45.

ing one of his fields, noticed an ear of better quality, being larger, with better filled grain, than the others around. This ear he selected and propagated in his garden.

The *Annat* barley originated from the produce of three ears selected by Mr Gorrie, Annat Gardens, hence its name.

The *four-rowed* or *common* barley is best known under the name of bere or bigg, and is confined chiefly to Northern Europe, and in this country to the north of Scotland, or to poor upland soils. There is also a *six-rowed* variety, but it is not extensively grown.

Uses of Barley.—The great bulk of the better samples of barley is used for distillery purposes, a small proportion being employed for the manufacture of pot barley or barley-meal, chiefly confined for use in Scotland. The inferior or damaged barley is used as food for animals.

Manuring Barley.—When it follows a well-manured root crop, as it generally does, barley seldom requires or receives any further manuring. Barley is a suitable crop for land on which a portion of the root crop has been consumed by sheep, and in this case the soil is usually in good heart, especially if the sheep have been allowed extra food, such as cake or grain along with the roots. The custom is to plough this land with a light or moderate furrow, and thus give the barley an abundance of readily available plant-food within the reach of its shallow roots.

But when the land has not, by previous treatment, become sufficiently stored with fertility for barley, this crop will, as a rule, respond satisfactorily to direct dressings of suitable manure. Being a rapid-growing shallow-rooted plant, barley should have plenty of readily available food within easy reach of the surface. Quickly acting artificial manures are thus specially suited for barley. Superphosphate and nitrate of soda, or sulphate of ammonia, in different quantities and proportions, according to the character and condition of the land, are extensively and advantageously used as top-dressing for barley. The first and last should be applied at seed-time; nitrate of soda, which acts more rapidly than sulphate of ammonia, may be applied in moist weather a few weeks later. Common quantities, per acre, are 2 to 3 cwt. superphosphate, and ½ to 1 cwt. of the nitrogenous manure. In many cases a light dressing of sulphate of ammonia or nitrate of soda is found to be very effective alone. In other cases a combined dressing of phosphatic, nitrogenous, and potassic manures gives the best results.

Rothamsted Barley Experiments.

The experiments on the manuring of barley at Rothamsted are full of interest to farmers. They have gone on continuously since 1852, and are capable of teaching some important lessons. Briefly summarised, the results are as follows:—

No Manure.—The plot which has had no manure of any kind since the beginning of the experiments gave an average of 17⅞ bushels for the thirty-two years up to 1883—4½ bushels less than the average of the first ten years.

Farmyard Dung.—Applied at the rate of 14 tons every year for thirty-two years, this gave for that period an average of 49½ bushels, or about 31½ over the unmanured plot.

Mineral Manures.—Mineral manures alone—that is, superphosphate of lime, and sulphates of potash, soda, and magnesia—gave very poor crops, both of grain and straw. Superphosphate alone, on an average of the thirty-two years, gave only about 5 bushels more than the plot with no manure; the increase from potash, soda, and magnesia over no manure was barely 2 bushels per acre, and from all these mineral manures combined scarcely 6 bushels.

Nitrogenous Manures.—These supplied in sulphate of ammonia or nitrate of soda gave more than double the increase produced by the mineral manures. Ammonia salts, 200 lb. per acre (containing 43 lb. nitrogen), gave an average of 30¾ bushels for the thirty-two years—nearly 13 bushels over the unmanured plot. Nitrate of soda, 275 lb. per acre (containing 43 lb. nitrogen), gave nearly 4 bushels more per acre. *Rape-cake*, 1000 lb. per acre, calculated to yield 49 lb. of nitrogen, raised the produce to 43¼ bushels.

Nitrogenous and Mineral Manures combined.—These in combination produced excellent crops, more than the

average of the country, continuously for thirty-two years. This result is very interesting, showing that barley responds admirably to the influence of readily acting artificial manures. Equal quantities of nitrogenous and mineral manures applied in the autumn to wheat, and in spring to barley, gave considerably more produce from the latter crop than the former.

Practical Conclusions.—From the results of the experiments with various manures for barley, it is inferred that in corn-growing the soil is most rapidly exhausted of its nitrogen, next of phosphates, and most slowly of potash. Nitrogenous manures are thus the first and cheapest essential, but, especially for barley, phosphatic manures are also required, and give a good return. To most soils of a clayey tendency, dressings of potash will be unnecessary for cereals; but where it is deficient, a small allowance may be expected to exercise a wonderful influence on the crop. Here, as in general farm practice, it was found that superphosphate is more effective with the spring-sown than with the autumn-sown cereals.

Barley after Corn.—In reference to the practice of growing barley after a crop of wheat, Dr Fream says:[1] "It may be laid down as a general rule, applicable to the country at large, that, on the heavier soils, full crops of barley of good quality may be grown with great certainty after a preceding corn crop, under the following conditions: The land should be got into good tilth. It should be ploughed up when dry, as soon as practicable after the removal of the preceding crop. In the spring it should be prepared for sowing by ploughing or scuffling, as early in March as possible, if sufficiently dry. The artificial manure employed should contain nitrogen, as ammonia or nitrate (or organic matter), and phosphates. From 40 lb. to 50 lb. of ammonia (or its equivalent of nitrogen as nitrate) should be applied per acre. These quantities would be supplied in 1½ cwt. to 2 cwt. of sulphate of ammonia, or 1¾ cwt. to 2¼ cwt. of nitrate of soda. With either of these there should be employed 2 cwt. to 3 cwt. mineral superphosphate of lime. Rape-cake is also a good manure for barley; from 6 cwt. to 8 cwt. would supply about as much nitrogen as would be equal to from 40 lb. to 50 lb. of ammonia. With this manure, as with guano, the addition of superphosphate is unnecessary. Whatever manure be used, it should be broken up, finely sifted, sown broadcast, and harrowed in with the seed."

[1] *Rothamsted Experiments*, 120.

SOWING OATS.

In Scotland and Ireland by far the greater portion of the ploughed lea is sown with oats—a small extent being sown in some parts with spring wheat or vetches, &c. In England oats are grown extensively after turnips or mangels, which have been carted off the land. And in all northern and high-lying districts unfavourable for the ripening of wheat or barley, oats are the prevailing crop after turnips.

Oats are sown on all sorts of farms, from the strongest clay to the lightest sand, and from the highest point to which arable culture has reached on moorland soil to the bottom of the lowest valley on the richest deposit. The extensive breadth of its culture does not imply that the oat is naturally suited to all soils and situations, for its fibrous and spreading roots indicate a predilection for friable soils; but its use as food among the agricultural population generally, and its suitability to support the strength of horses, have induced its extensive cultivation.

Varieties of Oats.—The oat plant thrives best in a cold climate, and is grown in the chief countries lying in the temperate zone. It comes to its greatest perfection in Scotland. This is to a certain extent due to the climate, but the care which the Scotch farmer expends upon his oat crop also contributes to this result. The varieties which occupy the greatest breadth are the Common Improved or White oats, and to a lesser extent Black or Tartarian. Common oat is the name by which farmers designate the variety which is commonly grown in the respective districts in which they farm. For instance, in the northern counties, Sandy oats are regarded as the Common oat; in Perthshire and western counties, late Angus;

in Roxburgh and Berwickshire, Blainslie, &c.

The following are the chief varieties: The Potato, Poland, Angus, Blainslie, Hopetoun, Sandy, Tartarian, Tam Finlay, Red and Dun oats, Canadian oats, Swiss oat, &c.

Sowing.—The sowing of the oat seed is begun with the common varieties of oats about the beginning of March. It is the custom in some parts to sow the improved varieties a fortnight after the common. The ploughed lea ground should be dry on the surface before it is sown, as otherwise it will not harrow kindly; but the colour of dryness should be distinguished from that arising from dry hard frost, a state improper to be sown upon. Every spot of the field need not be alike dry — even thorough draining will not ensure that, though spots of wet indicate where dampness in the subsoil exists.

Harrowing before Sowing.—Should the lea have been ploughed some time and from young grass, the furrow-slices will lie close together at seed-time; but when recently ploughed, or from old lea, or on clay land in a rather wet state, the furrow-slices may be as far asunder as to allow a good deal of the seed to drop down between them, and thus be lost, as oats will not vegetate beyond 6 or 7 inches deep in the soil. In such states the ground should receive a double tine or strip of the harrow before being sown. This should be done in every case unless the furrows are small and packed quite closely.

When oats are sown by hand upon dry lea ground, the grains rebound from the ground and dance about before depositing themselves in the hollows, in rows, accommodating themselves between the crests of the furrow-slices, and do not so readily show bad sowing as upon a smooth surface. Were the ground harrowed along the ridges, so as not to disturb the seed in the furrow-slices, the crop would come up as if sown by drill; but as the land is cross-harrowed, the braird comes up broadcast.

Quantity of Seed.—The quantity of common oats usually sown is from 4 to 5 bushels to the acre. In deep friable land in good heart, and in early districts, from 3 to 4 bushels of improved varieties is considered sufficient seed.

A man does a good day's work if he sows broadcast by one hand 16 imperial acres of ground in ten hours. Some men can sow 20 acres; and double-handed sowers will do even more than 20 acres.

Harrowing after Sowing. — The tines of the harrows should be particularly sharp when covering in seed upon lea. After the land is broken in with a double tine, it is harrowed across with a double tine, which cuts across the furrow-crests, and then along another double tine, and this quantity commonly suffices. At the last harrowing the tines should be kept clean from grassy tufts, and no stones should be allowed to be dragged along by the tines, to the injurious rubbing of the surface. On old lea, or hard land, another single tine across or angleways may be required to render the surface fine; and, on the other hand, on light soil a single tine along after the double one across may suffice. In short, the harrowing should be continued until the ground seems uniformly smooth and feels firm under the foot. The head-ridges are harrowed by themselves at the last.

Water-furrows.—If the land is liable to suffer from surface-water, *water-furrows* may be formed in the open furrow, after sowing. But since underground drainage has become so general and thorough, this practice has become almost a thing of the past.

Machine-sowing. — Almost every farm with two or more pairs of horses, and even smaller holdings, has its broadcast or drill sowing-machine. Hand-sowing is thus being replaced by the machine. The practice in sowing oats with machines, whether broadcast or drill, is similar to that in sowing wheat and barley. To enable the drill to make good work in sowing on ploughed lea, the surface must be well broken up with the harrow. Where the surface is rough, and the furrows tough, the broadcast machine would be preferable.

Improvements in Oat-culture.—Until a comparatively recent period the cultivation of oats was much neglected. The prevailing idea amongst farmers seemed to be that any kind of culture, no matter how slovenly, was good enough for this crop. Even yet, amongst the less advanced districts, no great improvement has been effected in this respect. It remained for the enlightened Scotch

farmer to lead the way towards placing the cultivation of this crop in its proper position, as being one of the most important operations of the farm.

One old writer informs us that "of all the plants commonly cultivated in the field, oats seem to have the greatest power of drawing nourishment from the soil, and hence, are justly considered as greatly exhausting the land;" and, by way of proof, he tells us that "oats are generally the last crop which would return any increase of the seed."

The principal reason is, we suspect, that oats are a deep-rooted plant, and can search for food over a greater area than the other corn crops.

Ploughing for Oats.—Difference of opinion exists as to the depth to which lea ground should be ploughed for oats. One opinion is that a depth of 4 inches is sufficient, with the furrow-slices laid down close; others contend that the land should be ploughed 9 inches in depth, and not laid over close. To determine which opinion is the more correct, it should be taken into account that the roots of oats are fibrous, and permeate through the soil to a greater depth than the roots of barley. This being their character, a good depth of furrow will be best for oats. Much of course will depend upon the depth and the character of the soil and of the subsoil; but as a rule, it is considered undesirable to plough lea shallower than 7 inches, to afford a considerable amount of pabulum to the roots of the plants.

Thick and Thin Sowing.—An uncertainty still exists in the minds of farmers whether thick or thin, drill or broadcast, sowing of oats is the better mode. Experiments have been made on both these points. Mr A. Bowie, Mains of Kelly, Forfarshire, sowed, in 1856, oats at 5 bushels and 2½ bushels the Scotch acre, on two farms, and the results were as follows:—

At West Scryne Farm.

Increase of corn after 2½ bushels per acre over 5 bushels	=6 bushels at 25s. per quarter,	£0	18 9
" straw " "	=95 stones imperial at 3½d.,	1	7 8
Saving of seed " "	=2½ bushels at 25s. per quarter,	0	7 9
	Total saving, . . .	£2	14 2

At Mains of Kelly Farm.

Increase of corn after 2½ bushels per acre over 5 bushels	=6¾ bushels at 28s. per quarter,	£1	3 7
" straw " "	=30 stones imperial at 4d. per st.	0	10 0
Saving of seed " "	=2½ bushels at 28s. per quarter,	0	8 9
	Total saving, . .	£2	2 4

Gross produce at Scryne after 2½ bushels per acre seed	= 11 quarters	2½	bushels.
" Kelly " "	= 10 "	0	"
Total, .	21	2½	

Gross produce at Scryne after 5 bushels per acre seed	= 10 quarters	4½	bushels.
" Kelly " "	= 9 "	1¼	"
Total, . .	19	5¾	

The land in both cases was pressed with the presser-roller. Experiments in drill-sowing with oats in Nairnshire gave these results:—

After 6 bushels per Scotch acre, 5 qrs. 24 lb.
" weight of grain 40½ lb. per bushel.
After 4½ bushels per acre, 6 qrs.
" weight of grain 39½ lb. per bushel.

In another experiment, where 4½ bushels of oats per Scotch acre were sown with the drill, and 6¼ bushels with the broadcast machine, the broadcast looked best throughout the season, but the drill produced 1 qr. 15/7 bushel per acre more. The experimenters recommend from 3½ to 4 bushels of oats, and 3 bushels of barley, of seed per acre.

Sowing Mixed Varieties.—Experiments have shown that a mixture of varieties of oats sown together may produce a heavier crop than when sown singly. For example: J. Finnie of Swanston obtained, when sown singly, from potato oats 74 bushels, Hopetoun 65, early Angus 63, sandy 56 to 61; whereas, when mixed, these results were obtained: Hopetoun 5 parts, and Kil-

drummie 1 part, produced 85 bushels; Hopetoun and sandy, 80; Hopetoun and early Angus, 76; potato and early Angus, 66; and potato and sandy, 66 bushels. It thus appears that potato oats alone produced 8 bushels more than when sown with either early Angus or sandy oats; that Hopetoun, with Kildrummie, produced 20 bushels more than when alone, with sandy 15 more, and with early Angus 11 more.

Thus an average of 13 bushels more per acre was obtained by mixing seeds of oats of different varieties than when sown singly, and that from a space of ground which took 6 bushels of seed.

It must be borne in mind that, in mixing varieties of oats, the varieties to be mixed should come to maturity at the same time. It would be interesting to hear this physiological difference between potato and Hopetoun oats explained—the potato yielding the larger produce by itself, while the Hopetoun required other varieties to stimulate it to a larger production.

Oats and Barley Mixed.—Another practice prevalent in the north of Scotland is to sow a mixture of barley and oats in the proportion of 4 bushels of oats to 1 bushel of barley. Good results ensue, especially on land where oats, after brairding, become thin or die out. The gross produce is greatly increased, and an excellent food for horses and cattle is obtained.

It is more than probable that the greater produce which is thus obtained from a mixture of oats and barley than from either alone, is that oats and barley search for their food in different layers of the soil—oats penetrating to a considerable depth, whilst barley confines its search mainly to the upper portion of the soil.

Manuring for Oats.—In its manurial requirements oats are not much different from barley. They abstract a little more nitrogen and potash, and about the same quantity of phosphoric acid. Oats require more moisture than either wheat or barley, and delight in soils enriched by decayed vegetable matter. Thus oats give large yields on land newly reclaimed, or on land which has been for a considerable time under grass.

Superphosphate of lime and nitrate of soda applied as a top-dressing give good results when the land requires manuring. The nitrate is specially useful when a bulky crop of straw is desired. Common dressings consist of from ½ to 1 cwt. of nitrate of soda, and from 1 to 2 cwt. of superphosphate. On light land a little potash is sometimes applied with advantage. Guano is also a capital dressing for oats.

But the practice of top-dressing oats is not general. The oat crop, indeed, receives less manure in direct applications than any of the other ordinary farm crops — that is, when the oats follow either grass or roots. Of course when the oats follow another corn crop some dressing is considered necessary.

ROLLING LAND.

The common land-roller is an implement of simple construction, the acting part of it being a cylinder of wood, of stone, or of metal. Simple, however, as this implement appears, there is hardly an article of the farm in which the farmer is more liable to fall into error in its selection.

From the nature of its action, and its intended effects on the soil, there are two elements that should be particularly kept in view—*weight* and *diameter* of the cylinder. By the weight alone can the desired effects be produced in the highest degree, but these will be always modified by the diameter. Thus, a cylinder of any given weight will produce a greater pulverising effect if its diameter is 1 foot, than the same weight would produce if the diameter were 2 feet; but then the one of lesser diameter will be much heavier to draw; hence it becomes necessary to choose a mean of those opposing principles. In doing this, the material of the cylinder comes to be considered.

Wood, which is frequently employed for the making of land-rollers, may be considered as least adapted of all materials for the purpose. Its deficiency of weight and liability to decay render it objectionable. *Stone*, though not deficient in weight, possesses the one marked disadvantage of liability to fracture. This of itself is sufficient to place stone

rollers in a doubtful position as to fitness. *Iron and steel* are undoubtedly the most appropriate of all materials for this purpose.

Diameter and Weight of Rollers.—There has been much discussion from time to time as to the most advantageous diameter for a land-roller. The preponderance of practical evidence is to the effect that a diameter of 2 to 2½ feet is, under every circumstance, the one that will produce the best effects with a minimum of labour from the animals of draught. In many cases, however, rollers of less as well as of greater diameter are in use. The weight is, of course, proportioned to the force usually applied, generally 1 but often 2 horses. The weight of roller, including the frame corresponding to this, is from 10 to 15 cwt. But some think it better that the roller itself should be rather under these weights, and that the carriage be fitted up with a box, in which a loading of stones can be stowed, to bring the machine up to any desired weight. Such a box is, besides, useful in affording the means of carrying off from the surface of the ground any large stones that may have been brought to the surface by the previous operations.

Divided Roller.—In a large and heavy roller, in one entire cylinder, the inconvenience of turning at the headlands is very considerable, and has given rise to the improvement of having the cylinder in two lengths. This, with a properly constructed carriage, produces a very convenient form of land-roller. Fig. 275 is a perspective of the land-roller con-

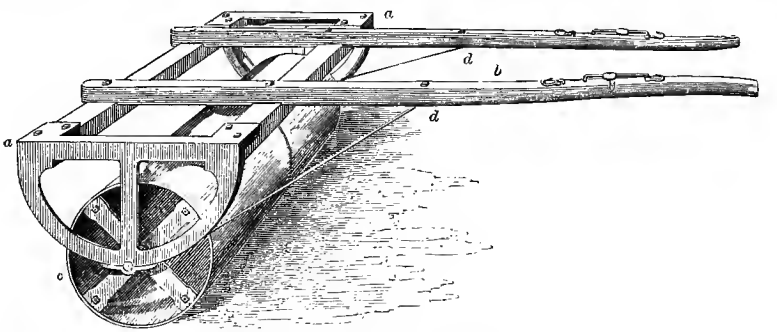


Fig. 275.—*Cast-iron land-roller.*

a a Carriage-frame. *b* Horse-shafts. *c* Cylinder. *d d* Iron stays.

structed on the foregoing principles, with the carriage-frame crossed by the horse-shafts. The cylinder is in 2 lengths of 3 feet to 3 feet 3 inches each, and 2 feet in diameter; the thickness of the metal is according to the weight required. The axle, in consequence of the cylinder being in two lengths, requires to be of considerable strength, and of malleable iron; upon this the two sections of the cylinder revolve freely, and the extremities of the axle are supported in bushes in the semicircular end-frames. Two iron stay-rods pass from the end-frames to the shafts as an additional support to the shafts.

Excellent rollers are now made of steel sheets fixed on wrought or cast-iron ends.

Water-ballast Roller.—A very convenient form of roller, made by Barford & Perkins, Peterborough, is represented in fig. 276. It is made in two enclosed cylinders of wrought iron, formed so that by filling or partially filling the cylinders with water, the weight of the roller may be varied as desired. These water-ballast rollers are made of many sizes for field and garden work, and are exceedingly convenient to work and move about. A water-ballast roller, 2 feet in diameter, weighs about 11 cwt. when empty, and 22 cwt. when quite full of water.

Process of Rolling.—The rolling is always effected across the line of ridges. Otherwise the open furrows would not receive any benefit from it. Although the dividing of the cylinder into two

parts facilitates the turning of the implement, it is not advisable to attempt to turn the roller sharply round, as part of the ground turned upon may be rubbed hard by the cylinders, with the result that young plants may be injured or killed.

The rolling is sometimes executed in feers of 30 yards in width, *hieing* the horses one-half of the feering, and *hupping* them in the other half. This, however, is unnecessary with care at the turning. When the ploughman becomes fatigued with walking, it may be allowable for him to sit on the front of the framing, where a space is either boarded or wrought with hard-twined straw-rope, as a seat from whence to drive the horses with double reins and whip. With this indulgence, an old ploughman, employed only in ploughing, could take the rolling when urgent work was employing the stronger horses in the cart.

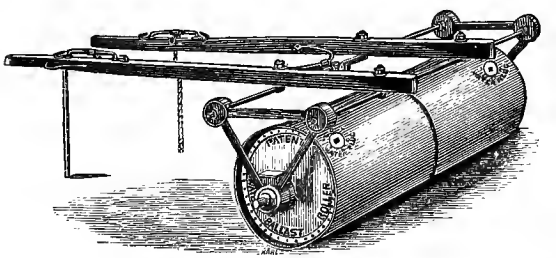


Fig. 276.—*Water-ballast roller.*

Speed in Rolling.—Were a 6-feet roller to proceed uninterruptedly for ten hours, at the rate of 2½ miles per hour, it would roll about 18 acres; but what with the time spent in the turnings and the markings-off of feerings, 10 to 12 acres a-day may be considered a good day's work. When the weather is favourable, and a large extent of ground has to be rolled, it is a good plan to work the roller from dawn to nightfall, each horse or pair, as the case may be, working 4 hours at a time. In this way, 16 hours' constant rolling, from 4 in the morning till 8 at night, may be obtained in the course of 24 hours, and from 25 to 30 acres rolled with one roller.

Time for Rolling.—The usual time for rolling is immediately after the seed has been sown. But the condition of the land as to moisture must be considered. The young braird on strong land is much retarded when the earth becomes encrusted by rain after rolling, so that such land in wet districts is in rainy seasons not rolled until the end of spring, when the plant has made some progress, and the weather continues dry. Light friable dry land should be rolled immediately after the seed is sown and harrowed, if there is time to do it. But the rolling of one field should not be allowed to cause delay in the sowing of others in dry weather. There will be plenty of time to roll the ground after the oat seed and other urgent operations at this season are finished.

On the other hand, the rolling is most effective in securing smoothness in the surface immediately after harrowing has been completed. And for the sake of the reaping-machine a smooth surface is of much importance.

In preparing land for grass and clover seeds the roller is not, as a rule, used so much as it should be. An even firm seed-bed is of the utmost importance for these tiny seeds.

GENERAL PRINCIPLES OF CORN CULTURE.

The sowing of the chief cereal crops has thus been dealt with very briefly. Much more might have been said on the subject, but there seems to be little necessity for describing at great length operations which are so simple as the cultivation of corn. Of all important work upon the farm this is, perhaps, the most simple and the most uniform in the methods of procedure.

The simplicity and the universality of the general principles of *corn cultivation* are well shown by Professor Wrightson in the following admirable epitome:—

"No business pursuit is easier than corn cultivation, and this is why we have such millions of bushels of corn thrown in upon us. It is a cheap cultivation. All we have to do is to plough the land, throw on the seed, and scratch it in. Of course we must do this at the right time of the year, and in the proper manner. When we take wheat or barley, or oats

[to be sown in the autumn or winter], after a root cropped on the land, a very general method of cultivation is as follows: We first plough about 4 inches deep, then broadcast the seed upon the newly turned up fallow, and put the harrows on and give it a really good harrowing, so as to break the compact furrow and cover the seed thoroughly—that is all. Protect it from the ravages of the birds, and in the spring of the year roll and harrow it, and that is pretty much the cultivation of corn after roots. A great deal of corn is taken after grass and clover crops; and the cultivation of either oats or wheat, or barley after lea, is much the same thing. We plough and press, and often sow the seed upon the pressed furrow and harrow it in.

"Again, in other cases we plough, press, or heavily roll, harrow repeatedly, and drill. That again is the whole of the cultivation. Corn crops sometimes follow peas or beans, in which case the plan would be to dung the surface, and then proceed as before, ploughing in the dung, and either broadcasting or else producing a proper seed-bed with the use of the harrow, and drilling in the corn."[1]

Insect attacks upon corn and other crops are dealt with in a special chapter.

CROSS-PLOUGHING LAND.

The first preparation for barley seed after turnips is ploughing the land across at right angles to the existing ridges. The surface of the ground where sheep consume turnips is left in a smooth state, trampled firm by the sheep, presenting no clods of earth but perhaps numbers of small round stones, which should be removed with carts before the cross-ploughing is begun. The small stones are useful for drains, or to repair farm roads, and the large stones for dykes.

A plough then feers the ground for cross-ploughing. The reason that land is cross-ploughed for barley, and not for spring wheat, after turnips eaten off by sheep, is, that wheat thrives best when the soil is firm and not too much pulverised —whereas the land cannot be in too fine a condition for barley. Moreover, if the turnip-land were not cross-ploughed after the sheep left it, their manure would not be sufficiently intermixed with the soil, and in consequence the barley would grow irregularly in small rows, corresponding to the drills that had been manured for the turnip crop.

Preparing Turnip-land.— During the time the land is gradually being prepared for barley seed, as the sheep clear the ground of turnips, the stubble-land, which had been ploughed in autumn and in winter, and is to bear green crops in the ensuing season, should be cross-ploughed, and cultivated, as opportunity offers—that is, if the sowing of the oat seed is also finished.

Harrowing before Cross-ploughing.—The portion of the stubble-land first to be cross-ploughed is for beans. Every winter-ploughed field for cross-ploughing in spring is freed from large clods by *harrowing*. The winter's frost may have reduced the clods of the most obdurate clay soil, and the mould-board of the plough may thus be able to pulverise them fine enough, while the lighter soils may have no clods upon them. In this case it would seem loss of time to harrow the ground before cross-ploughing, and some farmers do not then use the harrow; yet, in the majority of cases, the harrowing will be found beneficial. One cannot be sure that, in the strongest soil, all the clods have been reduced to the heart by frost; and should any be buried by the cross-furrow while still hard, they will not afterwards be so easily pulverised amongst the soft soil as when exposed upon the harder surface of the winter-furrow. Then in the lightest soils, the harrows not only make a smoother surface, but intermix the surface dry frost-pulverised soil with the moister and firmer soil below, as far as the tines of the harrows can reach.

There is not much time lost in harrowing before cross-ploughing; and although it should require a double tine to pulverise the clods, or equalise the texture of the ground, it should be *across* instead of along the ridges, to fill up the open furrows with soil, whether the land had been previously ploughed with gore-furrows or not.

If time presses, the feerings for cross-ploughing may be commenced by one plough almost immediately after the har-

[1] *Prin. of Ag. Practice*, 136.

rows have started; and if the harrows cannot get away before the plough, the plough can take a bout or two round the first feering till the harrows have reached the second feering; or, still better, the harrows can go along each feering, preparing the ground for the plough, and then return and finish the harrowing between the feerings.

Thus, in fig. 277, after the first feering *e f* across the ridges has been ploughed, the plough can either take a bout or two round *e f*, till the harrows have passed the next feering *g h*, or the harrows can

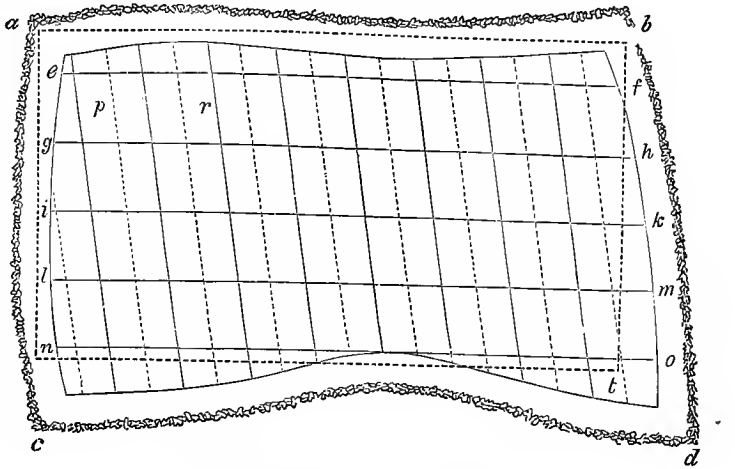


Fig. 277.—*Field feered for cross-ploughing.*

go along the line of each feering, at 30 yards' distance, first *e f*, then *g h*, then *i k*, and so along *l m* and *n o* in succession, and prepare the ground for feering, and then return and harrow out the ground between *e* and *g*, *g* and *i*, *i* and *l*, and *l* and *n*. In this way the harrowing and feerings, and ploughing the feerings, may go on at the same time.

System of Cross-ploughing.—But if time is not urgent, the systematic way is to feer the field across, at 30 yards' distance, from *e* to *n*, across the whole field, and the ploughs take up the feerings in succession. To illustrate this more fully, suppose that all or as much of the field to be cross-ploughed has been harrowed as will give room to a single plough to make the feerings without interruption. In choosing the side of the field at which the feerings should commence, it is a good rule to begin at the side farthest from the gate and approach gradually towards it, because then the ends of the finished feerings will not be passed, and the trampling of the ploughed land be avoided. The convenience of this rule is felt not in cross-ploughing only, but in prosecuting every kind of field-work; for besides avoiding damage to finished work, it is gratifying to the mind that, as work proceeds, the approach is nearer home; while it conveys the idea of a well-laid plan to have the operations of a field commenced at the farthest end and finished at the gate, where all the implements meet, ready to be conveyed to another field. The gate is like home, and in most cases it is placed on the side or corner of a field nearest the steading.

Ploughing Irregular Fields.—Peculiar forms of fields involve considerations in field operations of more importance than mere convenience—as loss of time. It is always desirable to commence a feering at a *straight* side of a field, whence in striking off the feerings parallel spaces of ground are included. Where this precaution is neglected, much time is needlessly spent in ploughing a number of irregular pieces of ground. It is better to leave all irregularities of ploughing to the last; and as an irregularity must occur along the side of a crooked fence, it is a saving of time to throw the irregular ploughing to that side.

In applying this rule to fig. 277, it so happens that the straighter side of the field is nearest the gate *b*, and the crooked feuce, *c* to *d*, farthest from it. The feering, therefore, should begin along the side of the straightest fence *a b*, and terminate in an irregular space along the crooked fence *c d*. A straight feering could, no doubt, be made at first near *c d*, leaving irregularities between it and the fence; but the setting off that feering *exactly parallel* with the straighter fence *a b*, to avoid making another irregularity at *a b*, would impose considerable trouble, and take up more time than the advantage would compensate for avoiding passing the ends of the ploughed ground along the side-ridge, *d* to *b*, or of working from the gate *b* instead of to it. Let the first feering, then, be made about 7 or 8 yards from the fence *a b*, or from the ditch-lip of the fence where there is a ditch.

Ploughing Ridges and Feerings.—Some farmers neglect the head-ridge in the cross-ploughing, and measure the feering from the open furrow which divides the head-ridge and the ends of the ridges. The head-ridges ought to be ploughed at this time along with the rest of the field, for, if neglected now, the busy seasons of spring and early summer will draw away attention from them, till, what with trampling in working the green crop and the drought of the weather, they will become too hard to plough, and will lose the ameliorating effects of sun and air in the best part of the year.

In cross-ploughing the ridges of the field, the head-ridges must be ploughed in length, for they can never be *cross*-ploughed. But if it be desired to plough the head-ridges with the side-ridges, which form the head-ridges in cross-ploughing, and the side-ridges must be ploughed before the crop can be sown upon them, the first feering should be struck at 7 or 8 yards down the ridges from the side of the head-ridge, in the line of *f e*; and *feering* is executed by throwing the furrow-slices right and left along the same furrow, as already described in feering ridges in fig. 33, p. 108, vol. i. The next feering is *h g*, at 30 yards' distance from *f e*, and so on, feering at every 30 yards' distance, to the last feering *o n*. As each feering is made, the ploughmen take it up in succession; and should the feerings have been finished before the ploughs entered the field, the ploughs all commence at once.

Ploughing the feerings is plain work; but a hindrance occurs at the last and irregular feering at *o n*—not that any intricacy is involved in ploughing irregular pieces of ground, but the loss of time is considerable. This feering is ploughed like the rest, till the open furrow of the head-ridge is reached; and if the head-ridges are included in the feerings, the ploughing goes on till the ditch-lip or fence is reached; but if the head-ridge is to be ploughed with the side-ridges, the last feering should be made at the open furrow of the head-ridge at *o n*, and the bent head-ridge will be ploughed with the side-ridges and upper head-ridge round the field without leaving any unploughed space at *s*. Had the field been a true rectangle, like the space included within the dotted lines *a n t b*, the feering might have been struck from either fence, and there would have been no loss of time in ploughing alternate long and short furrows.

Depth of Cross-furrow.—The depth of the cross-furrow varies with the character of the soil. It is often, in good soil, deeper than the winter-furrow. The deepness is easily effected by the plough passing under the winter-furrow and raising a portion of the fresh soil below it. If the under soil is suitable, the 2 inches of fresh subsoil mix well with the thicker winter-furrow.

Cross-ploughing the first furrow in spring is unsteady work for the ploughmen, the open furrows presenting little resistance to the plough compared with the crown of the ridge.

The depth of the cross-furrow may vary from 8 to 12 inches, 10 inches being quite common. Sometimes 3 horses are yoked in the plough, as in fig. 26, p. 97, vol. i., for cross-ploughing.

Grubbers or cultivators are now extensively employed in spring tillage. To these operations fuller reference will be found in the chapter dealing with sowing turnips.

SOWING GRASS SEEDS.

Any time after the middle of February until the middle of May, when the

weather is dry, grass seeds may be sown. They are generally sown in company with another crop; and the crops they accompany are cereals.

VARIETIES OF GRASSES.

The grasses all belong to the natural order *Graminecæ*. The following varieties are those principally used in agriculture, and for the descriptions of these we are indebted to Mr Martin H. Sutton, the author of 'Permanent Pastures,' as revised and greatly enlarged by his son, Mr Martin J. Sutton :—

Agrostis alba—*var.* stolonifera.

(Fiorin, or Creeping Bent Grass.)

Fr. *Agrostide blanche stolonifere.* Ger. *Fioringras.*

Roots creeping, rootstock perennial and stoloniferous. Stems 6 inches to 3 feet. Leaves numerous, narrow, flat, short, and usually scabrid; sheath smooth; ligule long and acute. Panicle spreading, with whorled branches. Spikelets small, one-flowered. Empty glumes larger than flowering glumes, unequal, smooth, and awnless. Flowering glumes slightly hairy at the base, with occasionally a minute awn. Palea minute and cloven at the point. Flowers from July to September. Grows in pastures and damp places throughout Europe, Siberia, North Africa, and North America (fig. 278).

Although none of the creeping bent grasses are considered particularly nutritious for cattle, yet this variety is sometimes desirable in permanent mixtures, in consequence of its value in affording herbage early in spring and late in autumn, before and after other grasses have commenced or left off growing. Its long fibrous roots and creeping habit are naturally adapted for moist situations.

Fig. 278.—Fiorin, or creeping bent grass (*Agrostis alba*, var. *stolonifera*).

Alopecurus pratensis.

(Meadow Foxtail.)

Fr. *Vulpin de prés.* Ger. *Wiesen Fuchsschwanz.*

Roots fibrous, rootstock perennial. Stems 1 to 3 feet, erect and smooth. Leaves flat and scabrid; sheath smooth and longer than its leaf; ligule large and truncate. Panicle spike-like, cylindrical, and obtuse. Spikelets one-flowered, and laterally compressed. Empty glumes larger than flowering glumes, awnless, but hairy on the keel. Flowering glumes with straight awn inserted at the middle of the back. Palea none. Flowers from the middle of April to June. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and North-western India (fig. 279).

Fig. 279.—Meadow foxtail (*Alopecurus pratensis*).

Meadow foxtail is one of the earliest and best grasses for permanent meadows and pastures, and may also with advantage be included in mixtures for 3 or 4 years' lea. It furnishes a large quantity of nutritive herbage, produces an abundant aftermath, and is eagerly eaten by all kinds of stock. The leaves are broad and of dark-green colour. The habit is somewhat coarse, hence it is unfit for

lawns or bowling-greens, but its very early growth recommends it as eminently suitable for ornamental park purposes. It succeeds best on well-drained, rich, loamy, and clay soils, makes excellent hay, and should be included in a larger or smaller proportion in most mixtures for permanent pasture. Meadow foxtail is admirably adapted for irrigation. It also flourishes under trees, and should be sown plentifully in orchards and shaded pastures.

Anthoxanthum odoratum.

(Sweet-scented Vernal.)

Fr. *Flouve odorante.* Ger. *Gemeines Ruchgras.*

Roots fibrous, rootstock perennial. Stems tufted, erect, 1 to 2 feet, glabrous, and with few joints. Leaves hairy, flat, and pointed; sheath ribbed and slightly hairy; ligule hairy. Panicle spike-like, pointed at summit, uneven below. Spikelets lanceolate,

Fig. 280.—Sweet-scented vernal (*Anthoxanthum odoratum*).

one-flowered. Empty glumes in two pairs; outer two much larger than the flowering glumes, unequal, hairy at the keels and pointed at the ends, but awnless; second pair shorter and narrower than first pair, equal; also hairy and both awned, one with short straight awn inserted at the back near the summit, the other with long bent awn inserted at the centre of the back. Palea adherent to the seed. Flowering glumes small, glabrous, and awnless. Stamens two. Anthers large. Flowers April and May. Grows in fields, woods, and on banks throughout Europe, Siberia, and North Africa (fig. 280).

To the presence of this grass our summer hay-fields owe so much of their fragrance that it should be included in all mixtures for permanent meadow or hay. The scent is less distinguishable in a fresh than in a dried state, but its very pleasant taste, somewhat resembling highly flavoured tea, is discernible at all stages of its growth. In point of productiveness, this grass is inferior to foxtail, cocksfoot, and other strong-growing varieties; but the quality is excellent, the growth very early, and the plant continues to throw up flowering stalks till quite late in the autumn. On account of the broad foliage, this grass is ill adapted for grounds where short grass is indispensable; but for parks and pleasure-grounds it is especially suitable, on account of its bright green colour. Pastures in which this grass abounds naturally (such, for instance, as the extensive sheep-grazing districts in Kent), produce the finest mutton; and, both in a young state and when mixed with other varieties, it is much relished by cattle and horses. It is valuable in hay, as its flavour enhances the price, and it also yields a good quantity of feed after the hay crop is cut. It constitutes a part of the herbage on almost every kind of soil, particularly on such as are deep and moist.

Avena flavescens.

(Yellow Oat-grass.)

Fr. *Avoine jaune.* Ger. *Goldhafer.*

Rootstock perennial, creeping, and somewhat stoloniferous. Stems 1 to 2 feet, erect,

Fig. 281.—Yellow oat-grass (*Avena flavescens*).

glabrous, and striated. Leaves flat, sheath slightly hairy; ligule truncate and ciliated.

Panicle spreading, with many branches, broad at the base and pointed at the summit. Spikelets small, three- or four-flowered, shining, and of a bright yellow colour. Empty glumes unequal, keeled, and rough. Flowering glumes hairy at the base and toothed at summit, with slender twisted awn springing from below the middle of the back. Palea narrow, short, and blunt. Flowers June, July, and August. Grows in dry pastures throughout Europe, North Africa, and Asia (fig. 281).

This grass may easily be discerned in July by its bright golden cluster of flowers, and is among the latest varieties in coming to maturity. The leaves are of a pale-green colour, hairy, and although they are not produced in great abundance, are much relished by cattle. It affords sweet hay, and yields a considerable bulk of fine herbage. After the crop is cut for hay, a large aftermath is produced. This grass thrives on calcareous land, but is useless in moist low-lying pastures.

Avena elatior.

(Holcus avenaceus, Arrhenatherum avenaceum.)

(Tall Oat-grass.)

Fr. *Arrhénathère élevée.* Ger. *Hoher Wiesenhafer.*

Rootstock perennial, widely creeping. Stems 2 to 4 feet, erect and smooth; leaves scabrid and flat; sheath smooth; ligule short and truncate. Panicle erect and sometimes slightly nodding at the apex, widely spreading during flowering, closed before and after. Spikelets two-flowered. Empty glumes unequal and pointed. Flowering glumes two, the lower with long twisted awn, the upper with short straight awn. Flowers June and July. Grows in meadows and pastures throughout Europe, Africa, Asia, and America.

A strong-growing and rather coarse grass of good feeding quality. The flavour is slightly bitter, and on this account cattle do not at first manifest a liking for it, but when mingled with other grasses the objectionable characteristic is imperceptible. Although this plant is classed among perennials, it cannot be relied on as strictly permanent, and therefore we do not advise its employment for a longer period than three or four years. For alternate husbandry, however, it may be freely sown among other grasses, and its presence will augment the weight of the crop. On poor thin land tall oat-grass is useless, but on drained clays and rich soils generally it grows luxuriantly. The plant is a gross feeder, and must be liberally treated to bring it to perfection. The seed needs to be buried more deeply than is safe with other grasses.

Cynosurus cristatus.

(Crested Dogstail.)

Fr. *Cynosure cretelle.* Ger. *Kammgras.*

Rootstock perennial, stoloniferous. Stems tufted, height 1 to 2 feet, erect, smooth, and wiry. Leaves very narrow, ribbed, slightly hairy; sheath smooth; ligule short and bifid. Panicle spike-like, secund. Spikelets many-flowered, ovate, flat, with a barren spikelet consisting of empty glumes arranged in a pectinate manner at the base. Empty glumes sharply pointed, shorter than flowering glumes, unequal, with prominent rough keels. Palea very thin, slightly ciliated. Flowering glumes lanceolate, with short awn at summit. Flowers July and August. Grows in dry hilly pastures throughout Europe, Western Asia, and North Africa (fig. 282).

Crested dogstail is a fine short grass, and constitutes a considerable portion of the herbage of sheep-walks and deer-parks. It is found in most meadows,

Fig. 282.—Crested dogstail (*Cynosurus cristatus*).

whether used for hay or grazing. Sinclair describes it as forming "a close dense turf of grateful nutritive herbage, and is little affected by extremes of weather." From our own experience and observation, we can fully indorse

the opinion of this eminent authority, and recommend its being included in all best permanent mixtures. We have especially noticed the beneficial results obtained by its use with other grasses in sheep-pastures; and it is generally believed that sheep fed on pastures containing dogstail are less liable to foot-rot than when fed on pastures composed of the more soft-leaved varieties. On account of its close-growing habit and evergreen foliage, it is particularly valuable for lawns, pleasure-grounds, and other places kept under by the scythe.

Dactylis glomerata.

(Rough Cocksfoot).

Fr. *Dactyle glomeré.* Ger. *Gemeines Knaulgras.*

Roots fibrous, rootstock perennial. Stems 2 to 3 feet, erect, stout, and smooth. Leaves glaucous, broad, flat, keeled, and rough; sheath scabrid; ligule long. Panicle secund, spreading below, close and pointed above. Spikelets three- to five-flowered, laterally compressed, and closely clustered at the end

Fig. 283.—Rough cocksfoot (*Dactylis glomerata*).

of the branches. Empty glumes smaller than flowering glumes, unequal, keeled, and hairy on upper part of the keel, pointed at the summit. Flowering glumes with hairy keel, pointed and ending in a short awn. Palea bifid at summit, and fringed at base. Flowers May to August. Grows in pastures, woods, orchards, and waste places throughout Europe, North Africa, North India, and Siberia (fig. 283).

This well-known grass grows luxuriantly in deep rich soils and low-lying meadows. For the enormous quantity of produce it yields, the rapidity with which it shoots forth again after having been eaten or cut, and also for the important fact of its being so much relished by horses and cattle, it is eminently suitable for sowing with other quick-growing grasses for alternate husbandry. It should be included in permanent mixtures for tenacious soils and damp situations; but in parks and ornamental grounds its tufty habit of growth renders it inadmissible. It withstands drought well, makes excellent hay, and succeeds under trees, &c. It is very useful for sowing in covers, if allowed to grow without checking.

Festuca pratensis.

(Meadow Fescue.)

Fr. *Fétuque de prés.* Ger. *Wiesen Schwingel.*

Rootstock perennial, creeping. Stems tufted, 18 inches to 3 feet high, erect and smooth. Leaves flat and smooth; sheath smooth;

Fig. 284.—Meadow fescue (*Festuca pratensis*).

ligule short. Panicle spreading, but closer and narrower than in *F. elatior*, with fewer branches. Spikelets many-flowered, lanceolate. Empty glumes, shorter than flowering glumes, unequal and acute. Flowering glumes rough, and slightly awned. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows on good pastures throughout Europe and Northern Asia (fig. 284).

One of the earliest, most nutritious, and productive of our natural grasses. Both in its green and dried state it is eagerly eaten by all kinds of stock. It is useful for 3 or 4 years' leas, but is especially suitable for permanent pasture purposes. It is more adapted for moist than dry soils; still it constitutes a considerable portion of the herbage of all high-class pastures. Meadow fescue is thus referred to by Commander Mayne, in his 'Four Years in British Columbia and Vancouver's Island': "Cattle and horses are very fond of *F. pratensis*, or sweet grass, and it has a wonderful effect in fattening them. I have seen horses on Vancouver's Island, where the same grass grows, which had been turned out in the autumn, brought in in April in splendid condition, and as fresh as if they had been most carefully treated all the time." Although particularly robust in habit, it never grows in large tufts, as is the case with some coarse-growing grasses. The hay from it is plentiful, and of excellent quality.

Festuca elatior.

(Tall Fescue.)

Fr. *Fétuque élevée.* Ger. *Hoher Schwingel.*

Rootstock perennial, stoloniferous or tufted. Stems 3 to 6 feet, erect and smooth. Leaves broad, flat, and smooth; sheath smooth; ligule short. Panicle diffuse and nodding. Spikelets half an inch long or more, many-flowered, lanceolate. Empty glumes shorter than flowering glumes, acute and unequal. Flowering glumes broad, rough, and toothed at the apex. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows in damp pastures and wet places throughout Europe, North Africa, and North America (fig. 285).

Some botanists consider the *F. elatior* and the *F. pratensis* to be identical, and these grasses are consequently to be found in many botanical works bracketed together as synonymous. There is, however, a decided difference, which is clearly manifest not only in the seed, but in the growth of the two varieties. The seed of the true *F. elatior* is broader and longer than that of *F. pratensis*. The growth, too, is more robust, of much greater size in every respect, and it will consequently produce a heavier bulk of hay or feed. The panicles also of the *F. elatior* are quite distinct from those of the

Fig. 285.—Tall fescue (*Festuca elatior*, var. *fertilis*).

F. pratensis, being branched, bent, and drooping, and composed of large clusters. Those of the *F. pratensis*, on the contrary, are decidedly upright in their early stages of growth, becoming slightly bent as the flower approaches maturity. On account of its luxuriant habit, we do not recommend the use of *F. elatior* where a fine turf is required; yet as a productive grass, and one which is greedily eaten by stock, it may form a part of permanent mixtures for moist and strong soils where the crop is intended for grazing, and also for irrigation purposes. It is admirably adapted for covers, in which its large seeds are useful as food.

Festuca heterophylla.

(Various-leaved Fescue.)

Fr. *Fétuque feuilles variées.* Ger. *Wechselblätteriger Schwingel.*

Roots fibrous, rootstock perennial, tufted. Stems numerous, erect, and smooth. Leaves various, dark green, lower ones folded, upper ones flat. Panicle diffuse. Spikelets many-flowered. Empty glumes unequal, shorter than flowering glumes, with prominent mid-rib and long awn. Flowers June and July. Grows in meadows and pastures throughout Central Europe ; introduced into Great Britain for cultivation in permanent pastures.

This species is a native of France, where it is extensively grown, and was introduced to England in 1814. It is well adapted to our climate, and is valuable for parks and ornamental grounds, for its beautiful dark-green foliage. It is also particularly suited to pastures, on account of its large bulk of herbage ; but it produces little feed the same season after mowing.

Festuca ovina.

(Sheep's Fescue.)

Fr. *Fétuque des brebis.* Ger. *Schaf Schwingel.*

Rootstock perennial, creeping or tufted. Stems 6 to 12 inches, erect, and densely tufted, rough at the upper part and smooth below.

Fig 286.—Sheep's fescue (*Festuca ovina*).

Leaves very slender, chiefly radical, upper ones rolled ; sheath smooth ; ligule long and bilobed. Panicle small, erect, contracted, and subsecund. Spikelets small, upright, and many-flowered. Empty glumes shorter than flowering glumes, unequal, and acute. Flowering glumes small, with minute awn. Palea toothed, with hairy nerves. Flowers June and July. Grows in dry, hilly pastures throughout Europe, Siberia, North Africa, North America, and Australia (fig. 286).

This grass is supposed to have received its specific name from Linnæus, on account of its being so much relished by sheep ; and Gmelin, the eminent Russian botanist, says that the Tartars generally pitch their tents during the summer months in close proximity to it, on account of its value to their herds. There is no question but that on good upland pastures, especially if used for sheep grazing, this grass should form a large proportion of the herbage. In produce it is inferior to some others, but deficiency in quantity is more than counterbalanced by its excellent nutritive qualities. From its remarkably fine foliage it is particularly suited for lawns and pleasure-grounds, which are constantly mown.

Festuca duriuscula.

(Hard Fescue.)

Fr. *Fétuque durette.* Ger. *Harter Schwingel.*

Rootstock perennial, creeping. Stems 1 to 2 feet, erect, and tufted, but less so than in *F. ovina*. Stem-leaves flat, lanceolate, and striated ; sheath downy ; ligule long. Panicle erect and spreading. Spikelets many-flowered, and larger than in *F. ovina*. Outer glumes lanceolate and unequal. Flowering glumes narrow, with a short awn. Palea

Fig. 287.—Hard fescue (*Festuca duriuscula*).

toothed, with hairy nerves. Flowers June and July. Grows in damp, hilly places throughout Europe, North Africa, Siberia, North America, and Australia (fig. 287).

This is one of the most valuable and important of the smaller fescues, and its presence in hay is generally indicative of superior quality. It comes very early, retains its verdure during long-continued drought in a remarkable manner, and is one of the best of pasture grasses. All kinds of stock eat it with avidity, but especially sheep, which always thrive well on the succulent herbage it produces. From the fineness of its foliage, and the fact of its resisting the drought of summer and cold in winter, it is eminently adapted for sowing in parks and ornamental grounds. A large quantity of food is produced after the grass is cut for hay.

Festuca rubra.

(Red Fescue.)

Fr. *Fétuque rouge.* Ger. *Rother Schwingel.*

Rootstock perennial, with long creeping stolons. Stems erect, 2 to 3 feet. Leaves flat and rolled; sheath hairy; ligule long. Panicle spreading, and slightly drooping at apex. Spikelets many-flowered, of a reddish colour. Empty glumes unequal. Flowering glumes lanceolate, with a short awn. Flowers June and July. Grows in dry low-lying places near the sea, throughout Europe, North Africa, Siberia, and North America.

Although this grass is considered by some to be merely a variety of *F. duriuscula*, altered in habit by frequent cultivation on dry soil, yet to the careful observer there will appear an appreciable difference between the two varieties. The leaves are broader, of darker colour than the *F. duriuscula*, while the growth is not so strong. The principal difference, however, is in the creeping habit of *F. rubra*, which enables it to live on loose, light, dry soils, where most other grasses fail. Its creeping roots penetrate so deeply into the soil, as to enable the plant to maintain a fresh and green appearance when other varieties are burnt up. It is particularly adapted for pastures by the seaside. The nutritive value of this grass when just in flower is much greater than at an earlier period.

Glyceria fluitans.

(Floating Sweet Grass.)

Syns.—Poa fluitans and Festuca fluitans.

Fr. *Glycérie flottante.* Ger. *Schwimmgras.*

Rootstock perennial, stoloniferous. Stems branched, floating or creeping, stout and smooth. Leaves short, flat, and broad; ligule long, broad and pointed at apex. Panicle erect and branching. Spikelets oblong and many-flowered. Empty glumes unequal, flowering glumes scabrid, and blunt at apex. Palea with ciliated nerves. Flowers July and August. Grows in damp places throughout Europe, Siberia, North Africa, and North America.

This grass is found growing naturally by the sides of ditches, pools, lakes, and rivers, and is perhaps the only water-grass which is eaten with avidity by both sheep and cattle. The leaves are narrow, of a pale green colour, and succulent. It is valuable for moist situations, and thrives especially in the Fen districts.

Lolium perenne.

(Perennial Rye-grass.)

Fr. *Ivraie vivace.* Ger. *Englisches Raygras.*

Roots fibrous, rootstock perennial, sometimes stoloniferous. Stems 1 to 2 feet, bent at the base, ascending, smooth, and slightly compressed. Leaves flat, narrow, and pointed; edges and upper surface scabrid; sheath smooth and compressed; ligule short and blunt. Panicle spiked. Spikelets sessile,

Fig. 288.—Perennial rye-grass (*Lolium perenne*).

distichous, and many-flowered. Empty glumes, only an outer one to each spikelet, except in the case of the upper spikelet, which has two, lanceolate, smooth, distinctly ribbed, and shorter than flowering glumes. Flowering glumes obtuse, ribbed, and with sometimes a minute awn. Flowers May and June (fig. 288).

There has since 1882 been much discussion as to the character and value of rye-grass, and the part which it should play in the formation of permanent and temporary pastures, the former in particular. In that year Mr C. D. L. Faunce de Laune of Sharsted Court, Sittingbourne, contributed a paper to the *Journal of the Royal Agricultural Society of England* (vol. xviii., sec. ser., part 1) "On Laying Down Land to Permanent Grass," and there he condemned rye-grass, and urged "the necessity of eliminating" it from all mixtures of seeds to be sown in the formation of permanent pastures. In the same publication and through other channels he continued his denunciation of rye-grass, stating that—"My observations lead me to believe that rye-grass is detrimental to the formation of new pasture, not only because it is a short-lived grass, but because, owing to the shortness of its roots, it exhausts the surface of the soil; and when it dies, the bare space left is so impoverished that, though grass seeds may germinate upon it, they fail to live unless highly manured by accident or on purpose."[1]

Mr de Laune has certainly formed excellent permanent pastures without the assistance of rye-grass, and it cannot be denied that much good has resulted, and more good will still result, from the discussion which he has aroused; for it is well known that farmers did not, as a rule, give sufficient attention to the selection of seeds for pastures, and it is also more than probable that rye-grasses sometimes bulked more largely in seed-mixtures than was desirable.

Mr W. Carruthers, consulting botanist to the Royal Agricultural Society, joined with Mr de Laune in the controversy, in so far as to contend that rye-grass is no more perennial than the wheat plant; that it would die out in two years unless kept free from seeding; and that it should therefore be excluded from permanent pastures. But he has recommended rye-grass for temporary pastures, and admits that if it were eaten close down and not allowed to seed, "they might keep it alive as long as they like."

But the attack upon this particular plant, which has occupied such a prominent place in British pastures, has not prevailed. It has, indeed, been successfully repelled by Dr Fream, Sir John B. Lawes, and others, who have demonstrated the important and significant fact that rye-grass with white clover form the dominant constituents of many of the finest old pastures in the country, including the celebrated feeding pastures of Leicestershire. The results of Dr Fream's investigations are recorded in the *Journal of the Royal Agricultural Society*, vol. xlviii., sec. ser., part 2.

Although we have deemed it necessary to give this bird's-eye view of the "Battle of Rye-grass," as the discussion has been aptly termed, we cannot remove rye-grass from its wonted place in grass-seed mixtures, whether for permanent or temporary pastures. As to the relative quantity of rye-grass and other grasses, hard-and-fast rules should not be insisted upon. The quantities we have stated will not suit equally well in all circumstances; and while some may think it well to use still larger quantities of rye-grass, others may perhaps find smaller give better results.

An article on perennial rye-grass in *The Field*, on November 20, 1886, contains the following information:—

"The modern evidence in favour of perennial rye-grass, proving it to be a true perennial, exists in the report, prepared for Sir John Lawes by Mr Willis, on the flora of a pasture in Leicestershire, near Market Harborough. I am able to give the following details:—

"After fencing off a portion of the pasture to exclude the cattle, the grass in the enclosure was allowed to grow for the purpose of being botanically examined, when it was found that 75 or 80 per cent of the whole herbage was composed of two species only—Lolium perenne (common rye-grass) and Trifolium repens (white Dutch clover).

"The meadow in question was selected as the best 'old pasture' of the district. Its soil was a 'maiden' yellow loam 3 feet deep, resting on gravel, which secured natural drainage. It had not been cut for hay within memory, and was depastured every year by the following extraordinary head of stock: Two sheep per acre throughout the winter, receiving

[1] *Jour. Royal Agric. Soc. Eng.*, xviii., sec. ser., part 2.

½ lb. cotton and linseed cake each daily for four months, and a little hay during latter part of winter when the grass is most scanty, and sixteen oxen, or one per acre and two over, entered early in April, and remaining till October or November, when they were fit for the butcher. The oxen received no extraneous food, except 6 lb. each daily of the same mixture of cake during the last month.

"It is a general remark that the pastures are good in proportion to the production of rye-grass and Dutch clover."

Lolium italicum.

(Improved Italian Rye-grass.)

Fr. *Ivraie d'Italie.* Ger. *Italienisches Raygras.*

Roots fibrous, annual. Stems 4 to 6 feet, erect, stout, and somewhat rough. Leaves broad and succulent. Panicle spiked, erect, and distichous. Spikelets many-flowered. Flowering glumes with long awns. Flowers June and July (fig. 289).

The Italian rye-grass was introduced into this country in 1831 by the late Charles Lawson. It is very distinct in its character and seed from ordinary rye-grass, and as it is not perennial, it is only suitable for alternate husbandry, and producing early feed in the spring for sheep and cattle; but in permanent pastures it is to be avoided entirely. For sewage cultivation it stands in the first rank of all forage plants.

It has produced extraordinary crops at various sewage farms. On account of its rapid growth, and for its succulent herbage, it is invaluable for early sheep feed. It may be sown with safety any time between the months of February and October. If alone, 3 bushels per acre is the quantity required; but if sown on a corn crop with clovers, a much smaller quantity will suffice. In the latter case, it should not be sown until the corn is up. The mode of cultivation is exceedingly simple—harrowing the ground before and after sowing, and rolling subsequently, being all that is required. If the land is in good condition, three or four heavy cuttings per annum may be obtained, even without liquid manure; but undoubtedly, the more manure applied, especially in liquid form, the more abundant the crop; and it is important that the liquid should be applied immediately after cutting.

It is a common notion that wheat will not answer after Italian rye-grass. The following opinion of the late Mr William Dickinson on this point is worth consideration: "Thirty sheep may be kept upon Italian rye-grass, fed through hurdles, upon as little land as ten can be kept upon the common system upon common

Fig. 289.—Italian rye grass (*Lolium italicum*)

grass; and the finest crops of wheat, barley, oats, and beans may be grown after the Italian rye-grass has been fed off the two years of its existence. *Wheat invariably follows the Italian—splendid crops are grown where wheat had not been grown before.*"

Phleum pratense.

(Timothy, or Meadow Catstail.)

Fr. *Fléol des prés.* Ger. *Timothygras.*

Rootstock perennial, somewhat creeping. Stems 1 to 3 feet, erect and smooth. Leaves short, flat, and soft; sheath smooth; ligule oblong. Panicle spike-like, cylindrical, elongate, and compact. Spikelets one-flowered, laterally compressed. Empty glumes larger than flowering glumes, equal, each with stiff hairs on the keel and a short scabrid terminal awn.

Palea minute and pointed. Flowering glumes awnless, toothed, and much smaller than empty glumes. Flowers end of June to August. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and Western Asia (fig. 290).

One of the most common of our meadow plants. In some parts of America it attains a great height, and forms the bulk of the grass hay of that country. In England it is largely cultivated in

Fig. 290.—Timothy (*Phleum pratense*).

conjunction with other strong-growing grasses. For early feeding timothy is superior to cocksfoot. It may be pastured for some time through the spring without damage to the hay crop. It succeeds well on soils of a moist and retentive nature, and is keenly relished by all kinds of stock, whether in a green state or made into hay. In addition to its usefulness for permanent pasture, it possesses a high value for alternate husbandry.

Poa pratensis.

(Smooth-stalked Meadow-grass.)

Fr. *Paturin des prés.* Ger. *Wiesen Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems 1 to 2 feet, erect, smooth, and rather stout. Leaves flat, rather broad and slightly concave at the tip; sheath smooth and longer than its leaf; ligule short and blunt. Panicle loose, spreading and pyramidal in shape. Spikelets compressed, four-flowered. Empty glumes much webbed, lanceolate, almost equal. Flowering glumes larger, webbed, keeled, and acute. Palea short. Flowers June and early in July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 291).

This variety in early spring presents a beautiful green appearance, and is easily distinguished from *Poa trivialis* by its smooth culms and leaves. Being of a more creeping habit than other Poas, it is sometimes condemned as exhausting the soil. On account of its unusual earliness and great productiveness at a period of the season when other grasses are comparatively dormant, it should be

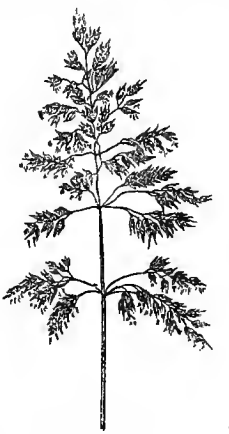


Fig. 291.—Smooth-stalked meadow-grass (*Poa pratensis*).

included in permanent pasture mixtures where early feed is of importance. *Poa pratensis* flourishes in dry soil, makes excellent hay and aftermath, and is valuable for garden lawns and ornamental grounds.

Poa trivialis.

(Rough-stalked Meadow-grass.)

Fr. *Paturin commun.* Ger. *Gemeines Rispengras.*

Rootstock perennial, somewhat creeping, but not stoloniferous. Stems 1 to 2 feet, rough and slender, erect. Leaves flat, narrow, acute, and rough; sheath rough and equal to its leaf; ligule long and pointed. Panicle loose, spreading and pyramidal in shape. Spikelets two- or three-flowered, and compressed. Empty glumes webbed, lanceolate, and nearly equal. Flowering glumes keeled and acute. Palea short and slightly fringed. Flowers June to end of July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 292).

This grass is somewhat similar in appearance to *P. pratensis*, but the two varieties differ materially in habit and general properties. It will be seen, on referring to the illustrations, that the flower-stems of the *P. trivialis* are slightly drooping in habit, while those of the *P. pratensis* are more erect; that the ligule (or small tongue) of the leaf in the former is pointed, while in the latter it is blunt. *P. trivialis* is adapted for good deep rich moist loams, stiff heavy clays, and irrigated meadows. It is unsuited for dry upland pastures, and if sown in such positions will soon disappear. Opinions differ as to the merits of this grass, some botanists declaring it to be only a second-rate variety. Our own experiments quite confirm Sinclair, who thus refers to it: "The superior produce of this Poa over many other species of grass, its highly nutritive properties, the season at which it arrives at perfection, and the marked partiality which horses, oxen, and sheep have for it, are merits which distinguish it as one of the most valuable of those grasses which affect rich soil and sheltered situations."

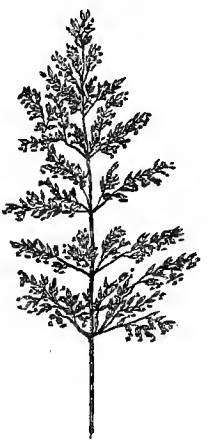


Fig. 292.—Rough-stalked meadow-grass (*Poa trivialis*).

Poa nemoralis sempervirens.

(Hudson's Bay, or Evergreen Meadow-grass.)

Fr. *Paturin des Bois a feuilles persistantes.* Ger. *Wintergrüines Hain Rispengras.*

Rootstock perennial, slightly creeping, but not stoloniferous. Stems 1 to 3 feet, erect, and smooth. Leaves narrow, pointed, rough on the surface and outer edges; sheath smooth; ligule none or very minute. Panicle diffuse, slender, and nodding; spikelets lanceolate, compressed. Empty glumes acute, nearly equal, sometimes slightly webbed. Flowering glumes rather large, lanceolate, with three hairy ribs. Palea with nerves slightly fringed. Flowers June and July. Grows in woods and shady places throughout Europe, Northern Asia, and North America (fig. 293).

The great recommendations of this grass are its perpetual greenness, and dwarf, close-growing habit. These qualities, as well as its reproductiveness, render it one of the very best varieties for lawns or pleasure-grounds, and the fact that it thrives under the shade of trees considerably enhances its value. It yields a good bulk of herbage, endures drought, and starts growth early in spring.

Fig. 293.—Evergreen meadow-grass (*Poa nemoralis sempervirens*).

Poa aquatica.

(Water Meadow-grass.)

Fr. *Paturin aquatique.* Ger. *Wasser Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems erect, smooth, and very stout. Leaves broad, rough, and with prominent ribs; ligule short and truncate; sheath smooth. Panicle spreading, with many branches. Spikelets many-flowered, oblong and compressed. Empty glumes unequal and short. Flowering glumes short, broad, and with prominent nerves. Flowers July and August. Grows in wet places throughout Europe, Siberia, and North America.

Poa aquatica grows luxuriantly in the Fen counties, where it forms a rich pasturage in the summer, and constitutes

the chief winter fodder. In districts which are wholly or partially flooded, it is entitled to increased attention. It may be cut three or four times a-year, and produces an immense quantity of herbage on soils which will not grow other grasses. The seed is generally scarce.

VARIETIES OF CLOVERS.

The clovers belong to the natural order *Leguminosæ*, genus *Trifolium*. The generic name is evidently derived from the triple leaves of the plants.

The following are the usually cultivated forms of *Trifolium* :—

Systematic Name.	Common Name.	Colour of Flower-head.
T. incarnatum	"Trifolium"	Crimson.
T. pratense	Meadow clover	Red or purple.
T. hybridum	Alsike	Pink and white.
T. repens	Dutch clover	White.
T. minus	Suckling clover	Yellow.

Importance of the Clovers.—This tribe includes, therefore, the most valuable herbage plants adapted to European agriculture—the white and red clovers. Notwithstanding what has been said of the superiority of *lucerne*, and of the excellence of *sainfoin* in forage and hay, the red clover for mowing, and the white for pasturage, excel, and probably ever will, all other plants.

Soils and Climate for Clovers.—The *soil* best adapted for red clover, *Trifolium pratense*, is deep sandy loam, which is favourable to its roots; but it will grow in any soil, provided it be dry. Marl, lime, or chalk promotes its growth. The *climate* most congenial to it is neither hot, dry, nor cold. Clover produces most seed in a dry soil and warm temperature; but as the production of seed is only in some situations an object of the farmer's attention, a season rather moist, provided it be warm, affords the most bulky crop of herbage.

Clover Seed.—Red-clover seed is imported into Britain from America, Germany, Holland, France, and even Italy, where it is raised as an article of commerce. What has been obtained from the last two countries has been found often too tender to stand an English winter. In Switzerland, clover seed is prepared for sowing by steeping in water or oil, and mixing it with powdered gypsum, as a preventive to the attacks of insects.

Perennial Red Clover.—The perennial red variety — *Trifolium pratense perenne*, or cow-grass — bears a great resemblance to the biennial in its general habits and appearance, and is thus accurately described in 'Permanent and Temporary Pastures,' Sutton, 2d edition, pp. 68, 69.

"*Trifolium pratense perenne* differs from broad clover in having a somewhat taller, smoother, and, except in its very young state, a less hairy stem, and a stronger, less fibrous, and more penetrating root. It carries its flowers some way above the foliage, surpasses

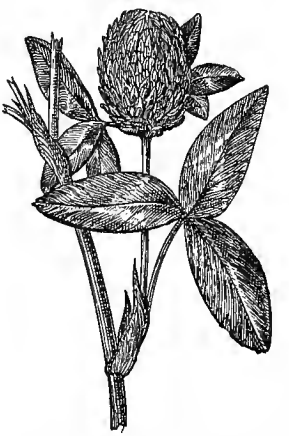


Fig. 294.—Perennial red clover (*Trifolium pratense perenne*).

broad clover in succulence and weight of crop, and stands frosts much better.

"The root of perennial red clover reaches down into the subsoil, enabling it to obtain moisture and nourishment in the hottest weather, when red clover gives up from drought. This penetrating habit also affords a means of sustenance to the plant on land which is too poor to grow broad clover, and makes it desirable to increase the proportion of this seed for pastures on thin uplands.

"Perennial red clover has two characteristics which greatly augment its value: it does not begin to flower until at least ten days later than broad clover, and its more robust and solid stems remain succulent and eatable by stock long after broad clover has become pithy and withered. Perennial red clover fills up the gap between the first and second cuttings of broad clover, coming into use at a time when there is no other available green food for the horses of the farm, but it rarely gives a second crop of any consequence.

"Cow-grass produces comparatively little seed from its single crop; whereas red clover yields a good crop of seed from the second cutting, after the first has been taken as fodder. For these reasons, seed of the perennial variety is necessarily high in price."

Sinclair says, in his 'Hortus Graminens Woburnensis': "In the fertile grazing lands between Wainfleet and Skegness in Lincolnshire, this true perennial red clover (*Trifolium pratense perenne*) is abundant. . . . Last summer, when examining the rich grazing lands in Lincolnshire, I found this plant to be more prevalent than any other species of clover. . . . The natural appearance of this plant in these celebrated pastures is such as to recommend it strongly for cultivation. It being strictly perennial, and the root only slightly creeping, it may be used for the alternate husbandry, for which the *Trifolium medium* is inadmissible on account of its creeping roots, constituting what, in arable lands, is termed *twitch*. . . . The nutritive powers of this species are superior to those of the *Trifolium medium*. . . . It thrives better when combined with other grasses than when cultivated by itself; but this, indeed, is also the case with all the valuable grasses. . . . The slightly creeping root remains permanent in the experimental garden, while the roots of the common broad-leaved clover have almost disappeared in the third season from sowing. For permanent pasture, therefore, this variety (*Trifolium pratense perenne*) is the only proper one to cultivate."

Fig. 295.—Red or broad clover (*Trifolium pratense*).

Meadow Trefoil.—*Trifolium medium*—meadow trefoil—is often confounded with perennial red clover, otherwise so worthless a weed would never have been recommended as a valuable constituent for our permanent pastures on light soils, where it never fails, by its obtrusive character, to destroy the more valuable pasture-plants around it. Sinclair owns that "the *Trifolium medium* is inadmissible in alternate husbandry, on account of its creeping roots, constituting what, in arable lands, is termed *twitch;*" and the twitch is most abundant, and there-

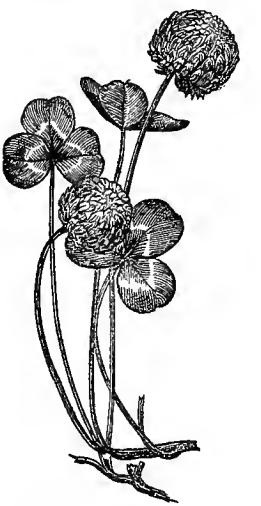


Fig. 296.—Perennial white clover (*Trifolium repens perenne*).

fore most troublesome, in light soils, not only in arable fields, but in pasture, where it usurps the place of better plants.

Creeping Trefoil.—*Trifolium repens*—creeping trefoil, Dutch white, or sheep's clover — is indispensable for low-lying pastures, and is, indeed, better adapted to pastures than to meadows. Curtis affirms that a single seedling covered more than a square yard of ground in one summer.

White Clover.—White clover is sometimes called shamrock, but it is not the true Irish shamrock. In the eastern counties it is called white suckling, which fact causes it to be confounded with *Trifolium minus*—yellow suckling, which latter plant in Norfolk and Suffolk, singularly enough, is invariably called red suckling.

Alsike Clover.—*Trifolium hybridum*—hybrid trefoil, Alsike clover—is a species possessing the properties of the red and white clovers, and was considered by Linnæus a hybrid between them. It

Fig. 297.—Alsike clover (*Trifolium hybridum*).

is a native of the south of Europe, but has been introduced into the agriculture of Germany and Sweden, where it is cultivated to considerable extent in the district of Alsike. Its average duration is three years, it resists cold well, it thrives in moist lands and under irrigation, but is susceptible to drought.

Trifolium incarnatum.—*Trifolium incarnatum*, a most beautiful dark crimson-flowered clover; makes good food for cattle, and grown with winter barley, or sown alone on wheat stubbles in August, it makes excellent fodder for sheep in the month of May. It is strictly an annual, and can never be sown without risk north of the Humber. There are now in cultivation four distinct varieties — *T. incarnatum*, *T. incarnatum tardum*, *T. incarnatum tardissimum Suttoni*, and *T. tardissimum album*.

By sowing all these varieties at the same time in the autumn, the period during which Trifolium can be fed or cut, the following summer will be extended to at least a month. Whereas, when the early Trifolium is sown alone, it has to be all consumed in about a week, to prevent its getting pithy and worthless.

Trifolium minus—yellow suckling—is often confounded with *Medicago lupulina*, yellow or hop trefoil. Suckling,

Fig. 298.—Common yellow clover or trefoil (*Medicago lupulina*).

however, is much harder, and more wiry in the stem, darker in the foliage, and has paler flowers than the *Medicago*. Although an annual or biennial, it is much more suited for permanent pastures than trefoil is, and is equally at home on dry soils and strong land.

Medicago lupulina.—Although not a *Trifolium*, no account of the agricultural clovers would be complete without reference to this plant, commonly known under the names of trefoil, black medic, or hop clover. This is the earliest of all the clovers to come to maturity in spring. On calcareous soils it is invaluable.

These are all the species of clover that

seem to deserve special notice, out of 166 described by botanists.[1]

Impurities in Clover.—The most frequently occurring impurities in samples of clover seed are the seeds of dodder, plantain, sorrel, dock, cranesbill, wild carrot, self-heal, corn bluebottle, chickweed, chamomile, and scorpion grass.

Varieties of Grasses sown.—For one year's lea it has been usual for them to consist only of red clover, *Trifolium pratense;* white clover, *Trifolium repens;* rye-grass, *Lolium perenne;* Italian rye-grass, *Lolium Italicum;* and, on light soils, the yellow clover, *Medicago lupulina.* These, in common parlance, are called the *artificial grasses*, because they are sown every year like any other crop of the farm, and are of temporary existence.

But of late it has been found very desirable to include other strong-growing perennial varieties, such as cocksfoot and Timothy, even where the mixture is to remain down but one season, and they are still more indispensable for 2, 3, 4, or 6 years' leas. The quantities sown vary but little over the country. The seeds are proportioned according as the grasses are to remain for one year or longer.

Seeds for Rotation Grasses.

Every county and district has peculiarities of climate and soil, which should be taken into consideration when deciding upon the exact varieties and proportions of the grasses and clovers sown. But the following mixtures will generally be found a useful standard to work by.

For *One Year's Lea.*—Where clovers are to be sown alone, 16 lb. should be sown per acre, in the following proportions:—

	lb.
Trefoil	5
White clover	1½
Alsike	2
Red clover	6½
Suckling	1

At a cost of about 12s. per acre.

Where rye-grass is the only grass used, 20 lb. in all should be sown, and the following will be found a desirable prescription:—

	lb.
Rye-grass	8
Red clover	8
Trefoil	3
White clover	½
Suckling	½

Costing about 12s. 6d. per acre.

But a far better prescription (20 lb. in all), and one costing no more, is the following:—

	lb.
Cocksfoot	½
Rye-grass	4½
Italian rye-grass	3
White clover	1
Red clover	4½
Suckling	½
Alsike	1
Trefoil	4
Timothy	1

Two Years' Lea.—When a lea has to remain down for two seasons, a slightly heavier seeding is required, and 24 lb. in all should be sown. The following is an extremely useful prescription:—

	lb.
Cocksfoot	2
Rye-grass	6
Italian rye-grass	4
Timothy	3
Red clover	2½
Alsike	3
Trefoil	2½
Suckling	1

This will cost about 14s. 6d. per acre, but must not be depended upon for more than two years.

For 3 *or* 4 *Years' Lea* other valuable grasses, like foxtail, meadow fescue, and lucerne, may be included with advantage: 32 lb. should be sown per acre, made up as follows:—

	lb.
Foxtail	1
Cocksfoot	2
Meadow fescue	1
Rye-grass	12
Italian rye-grass	4
Timothy	2½
White clover	2
Cow-grass	3
Alsike	1
Suckling	1
Lucerne	1½
Trefoil	1

Costing about 20s. per acre.

For 5, 6, *or* 7 *Years' Lea*, from 36 lb. to 40 lb. of seed should be sown per acre, and may consist of the following:—

[1] Don's *Gen. Sys. Garden. Bot.*, ii.—"Legumen."

	lb.
Perennial rye-grass	12
Italian rye-grass	8
Foxtail	1
Meadow fescue	2
Hard fescue	3
Smooth-stalked meadow-grass	2
Cocksfoot	2
Timothy	2
Cow-grass	1½
White clover	1½
Suckling	1
Lucerne	½
Trefoil	2½
Alsike	1

At a cost which need not exceed that of the foregoing mixture.

The process of sowing these temporary mixtures is so identical with that practised in the sowing of permanent grasses, that the whole subject may be treated under one head.

Grasses and Clovers for Permanent Pasture.

In Great Britain the laying down of land to permanent pasture steadily increased during the twelve years up till 1888, when the area under permanent grass amounted to considerably more than one-half of the cultivated land of the United Kingdom. With the decline in the price of wheat there is every reason to believe that the area of permanent pasture will continue to increase. Still, soil and climatic influences must determine in a great measure the extent of arable land that can with profit be converted into permanent pasture. Districts like the eastern and southern parts of England, being dry, are better adapted for corn than grass, and a glance at the returns for the various counties will show that the proportion of land under grass is smallest where the rainfall is lightest. In the western and northern districts, where the rainfall is heavy and strong lands abound, the summer is colder, and thus grass preponderates.

Permanent seeds like lea mixtures are generally sown in corn, and a wheat plant is perhaps best for this purpose, though oats and barley are much more commonly chosen.

Grasses for different Soils.—It is impossible to give exact advice as to the kinds and quantities of grasses and clovers required, in consequence of the extreme diversity of the soils of the country, but the following table will help greatly to determine which varieties are most suitable for any particular soil under consideration. An ample seeding per acre is 28 lb. of the larger grasses and 12 lb. of clovers, &c.; and nearly all prescriptions include the following varieties:—

Grasses.	Especially suitable for—
Agrostis stolonifera (fiorin)	Heavy and alluvial soils.
Alopecurus pratensis (meadow foxtail)	Rich deep soils.
Anthoxanthum odoratum (sweet vernal)	Medium and light soils.
Avena elatior (tall oat-grass)	All soils.
Avena flavescens (yellow oat-grass)	Dry and calcareous soils.
Cynosurus cristatus (crested dogstail)	Medium and light soils.
Dactylis glomerata (rough cocksfoot)	All soils.
Festuca duriuscula (hard fescue)	Medium, light, and thin soils.
Festuca elatior (tall fescue)	Deep heavy soils, and clays.
Festuca heterophylla (various-leaved fescue)	Rich deep soils.
Festuca ovina (sheep's fescue)	Calcareous and thin soils.
Festuca pratensis (meadow fescue)	Medium and heavy soils.
Lolium perenne (perennial rye-grass)	All soils.
Phleum pratense (timothy grass)	Deep heavy soils, clays, and alluvial.
Poa nemoralis (wood meadow-grass)	Rich medium soils.
Poa pratensis (smooth meadow-grass)	Light thin soils.
Poa trivialis (rough meadow-grass)	Rich, heavy, and alluvial soils.

Standard Seed Mixtures.—The following prescriptions may be considered very safe standards:—

Good Loamy Soil.

	lb.
Foxtail	2½
Sweet vernal	½
Cocksfoot	4
Meadow fescue	3½
Various-leaved fescue	1
Sheep's fescue	1½
Hard fescue	3
Red fescue	2
Perennial rye-grass	9
Smooth-stalked meadow-grass	½
Rough-stalked meadow-grass	1
Wood meadow-grass	½
Dogstail	½
Timothy	2½

Lucerne	1
White clover	2½
Cow-grass	2
Alsike	1½
Suckling	½
Yarrow	¼

Costing about 35s. per acre.

Gravelly Soil.

	lb.
Fiorin	½
Golden oat-grass	½
Sweet vernal	½
Cocksfoot	2
Meadow fescue	2
Various-leaved fescue	½
Sheep's fescue	1½
Red fescue	3
Hard fescue	3½
Perennial rye-grass	9
Smooth-stalked meadow-grass	3½
Wood meadow-grass	1½
Dogstail	1½
Timothy	1
Lucerne	1
White clover	2
Cow-grass	2
Trefoil	1
Suckling	3
Yarrow	¼
Lotus corniculatus	¼

Costing about 32s. per acre.

Clay Soil.

	lb.
Fiorin	2
Foxtail	4
Cocksfoot	4
Meadow fescue	3
Tall fescue	1
Various-leaved fescue	2
Hard fescue	1½
Perennial rye-grass	9
Rough-stalked meadow-grass	1½
Timothy	4
White clover	1
Cow-grass	2½
Alsike	3
Trefoil	1½

Costing about 36s. per acre.

Peaty Soil.

	lb.
Foxtail	2
Agrostis	4
Cocksfoot	2½
Tall fescue	1
Meadow fescue	4½
Water meadow-grass	1
Smooth-stalked meadow-grass	2½
Rough-stalked meadow-grass	1½
Timothy	3½
Perennial rye-grass	9
Trefoil	3½
Alsike	1½
White clover	1½
Cow-grass	2

Costing about 34s. per acre.

Mr De Laune's Mixtures.

In the description of rye-grass reference will be found to the objections raised by Mr Faunce de Laune to the inclusion of rye-grass in seed mixtures for permanent pastures. Although, as indicated there, good reason has been shown why farmers should still put faith in rye-grass, it may nevertheless be of interest to produce here the particular mixtures of seeds recommended by Mr De Laune for the formation of permanent pastures on different soils. They are as follows:[1]—

	Good or Medium Soils. lb. per acre.	Wet Soils. lb. per acre.	Chalky Soil. lb. per acre.
Foxtail	10	4	...
Cocksfoot	7	10	14
Catstail	3	3	3
Meadow fescue	6	3	2
Tall fescue	3	8	...
Crested dogstail	2	2	5
Rough meadow-grass	1½	2	...
Hard fescue	1	1	4
Sheep's fescue	1	...	4
Fiorin	1½	2	...
Yarrow	1	1	2
Golden oat-grass	...	...	1
Perennial red clover	1	1	1
Cow-grass	1	1	...
Alsike	1	1	1
Dutch clover	1	1	1
Total lb.	41	40	38

As the germination of the seed and the equal distribution of the plant depend upon the accuracy of the process, the details of sowing should be carried out with due regard to the serious loss which failure certainly entails.

Time of Sowing.—The best time for sowing depends much upon the weather, and no hard-and-fast period can be named. April may be properly regarded as a safe and favourable month in which to sow; but if the seed-bed is ready, and the land in working order by the middle of March, there need be no scruple as to putting in the seed. Sowing before is better than immediately after a shower, even supposing the land can be worked soon after rainfall. The seeds sown before rain gradually absorb moisture from the soil and dew until wet weather

[1] *Jour. Royal Agric. Soc. Eng.*, xviii., sec. ser., part 1.

sets in, and then the plants spring up with great rapidity. To sow later than the middle of May is most hazardous.

Methods of Sowing.—Grass seeds are sown by hand and with machines. The hand-sowing is confined mainly to small farms, while on moderate and large farms the machine is almost universally used.

Hand-sowing.—Sowing grass seeds by hand is a simple process, although it requires dexterity to do it well.

Clover and rye-grass seeds are so different in form and weight, that they should never be sown at one cast. The sower has little control over the grass seed, the least breath of wind taking it wherever it may. His sole object is to cast the seeds equally over the surface, and, as they cannot be seen to alight on the ground, he must preserve the strictest regularity in his motions. Being small and heavy, the clovers, even in windy weather, may be cast with tolerable precision. It is pleasant work to sow grass seeds by the hand. The load is comparatively light, and the ground having been harrowed fine, and perhaps rolled smooth, the walking is easy.

Machine-sowing. — But now the grass-seed broadcast sowing-machine, fig. 260, has superseded the necessity of hand-sowing on most farms. This is a most perfect machine for sowing grass seeds, distributing them with the utmost precision, and to any amount, and so near the ground that the wind affects but little even the lightest grass seed. Its management is easy when the ground is ploughed in ordinary ridges. The horse starts from one head-ridge, and walks in the open furrow to the other, while the machine is sowing half the ridge on each side, the driver walking in the furrow behind the machine, using double reins. On reaching the other head-ridge, the gearing is put out of action till the horse, on being *hied*, enters the next open furrow from the head-ridge; and on the gearing being again put on, the half of a former ridge is sown, completing it with the half of a new one by the time the horse reaches the head-ridge he started from. Thus 2 half-ridges after 2 half-ridges are sown until the field is all covered.

The seed is supplied from the head-ridge, upon which the sacks containing it were set down when brought from the steading.

The head-ridges are sown by themselves. But the half of the ridge next the fence on each side of the field cannot

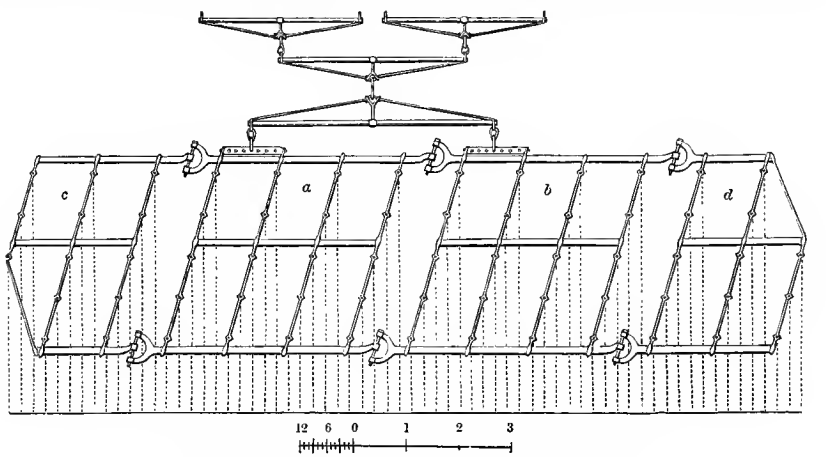


Fig. 299.—*Grass-seed iron harrows, with wings and swing-trees.*
a b Main leaves of the harrows. *c d* The 2 wings.

be reached by the machine, and must be sown by hand.

When ridges are coupled together, the horse walks along the middle between the crown and open furrow, the furrow-brow being the guide for one end of the machine, and 2 ridges are thus sown at every bout. Where ridges are ploughed

in breaks of 4 ridges in width, the furrow-brow is the guide in going and the crown in returning, while sowing 2 of the ridges; and the crown in going and the furrow-brow in returning, while sowing the other 2 ridges.

Speed of the Sowing-machine.— Were this machine to sow without interruption for 10 hours, at the rate of 2½ miles per hour, it would sow about 45 acres of ground; but the turnings at the landings, and the time spent in filling the seed-box with seed, cause a large deduction from that extent.

Grass-seed Harrows. — After the grass seeds are sown, the ground is harrowed to cover them in. For this purpose lighter harrows are better than the ordinary, which would bury clover seeds too deeply in the ground. These light harrows are arranged (with wings) to cover a large breadth at a time, so that the sowing of grass seeds is a speedy process. Fig. 299 is grass-seed harrows, with wings, covering a ridge of 15 feet wide at one stretch. The harrows have

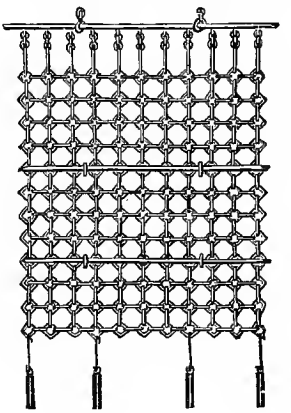


Fig. 300.—*Chain harrows.*

a set of iron swing-trees. Modern English harrows well suited for covering grass seeds are shown in fig. 300, made by Woodrooffe & Co., Rugeley.

Working wide Harrows. — Some dexterity is required to drive these wide grass-seed harrows. They should not be moved from one ridge to the adjoining, as part of the implement would then have to turn upon a pivot, which might wrench off a wing. Besides, it is inconvenient to *hup* the horses with these harrows. To avoid the inconvenience is to *hie* the horses at the end of the landings, round an intermediate unharrowed ridge.

Harrow Carriage. — Fig. 301 is a convenient and safe form of carriage for conveying harrows. This is much better for the purpose than the ordinary cart.

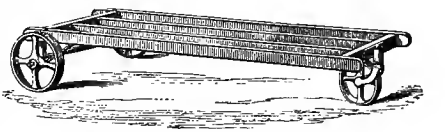


Fig. 301.—*Carriage for conveying harrows, &c.*

It consists of a frame of wood sparred in length to take on a pair of harrows coupled with their master-tree, and in breadth 3½ feet. The hind part of the frame rests on crutches supported upon the axle of 2 wheels, the upper part of the rim of which is below the top part of the frame; and the fore part rests upon a castor, which allows the carriage to be turned when desired. A horse, to draw the carriage, is yoked to 2 eyes of the fore-bar of the frame by the hooks of the plough-chains. The harrows are piled one above the other on the framing. Such a carriage may convey other articles to and from the fields.

Rolling for Grass Seeds.—The importance of thorough rolling in sowing grass seeds is not fully realised by the general body of farmers. It is of great moment that the small seeds should have an even firm bed, and this can best be secured by rolling, which also helps to retain the moisture in the soil, a matter of great importance in dry soils.

Rough land, if dry enough, should therefore be rolled before the grass seeds are sown. The rolling will reduce the clods before they become hard, and give a kindly bed to the small seeds. If the land is naturally dry, the roller is the more required to consolidate it after the winter's frosts. On light loams and turnip soils, the roller is often with advantage used, both before and after sowing, the ground getting a turn of light harrows after receiving the seed.

When strong land is in a waxy state, between wet and dry, the rolling had better be deferred, while sowing the

grass seeds may proceed, if the season, or state of the crop amongst which the grass seeds are to be sown, is already sufficiently advanced.

Crops accompanying Grass Seeds.—The cereal crops, amongst which grass seeds are sown, are winter wheat, spring wheat, oats, and barley. Wheat on bare-fallow clay sometimes grows so strong as to injure the young plants of grasses before it is reaped, but in lighter soils they are always safely sown amongst it. There is little fear of spring wheat attaining to such growth as to injure the grasses amongst it. Oats are the usual vehicle by which to introduce grass seeds to the ground. Remaining but a short time on the ground, they permit young grass plants to grow considerably before winter, and become able to withstand the vicissitudes of that season. Barley, in some seasons, grows rank and thick, so as to endanger the existence of the grasses. Barley, treated as oats, receives grass seeds in the same way; but for some reason or other, grasses do not thrive so well with barley as with oats.

Unless the winter wheat is too forward, the latter end of March will be the best time to put the grasses in. If the plant is strong, the common harrows will be required to obtain a hold of the ground; if weak, and the ground tender, the grass-seed harrows will be better.

Harrowing the Wheat-braird.—Winter wheat will be all the better for a harrowing in spring, even although some of the plants should be torn up by the tines, as it loosens the ground compressed by the rains, and admits the air to the roots of the plants. After such a harrowing, rolling will press the weak plants into fresh earth, and induce an immediate tillering from the roots; but should the plants have grown rank, the rolling should be dispensed with, in case of bruising the stems. The difference between bruising and bending the stems of wheat by rolling should be considered, so that rolling be done or left undone. A cereal crop, on a rolled surface, affords great facility for being reaped at harvest.

Many farmers sow grass seeds without harrowing them in, trusting that they may find their way into the soil amongst the clods, and be covered by their mouldering. But the safe and correct practice is to cover every kind of seed when sown.

Sowing with Spring Crops.—Although double-harrowing across prepares the land on which spring wheat is sown for the grass seeds, these are not sown whenever the wheat is sown. The wheat may be sown any time during winter or early spring, when the state of the weather and soil permit. But when wheat is sown at the latest period, the grass seeds should not only be sown then, but also amongst the spring wheat previously shown; as also amongst the winter wheat, should there be any in the same field.

It is worthy of consideration, in fields in which wheat has been sown at different times, that the latest sown should first be sown with grass seeds, then the next latest, and so on to the winter wheat. The reason for this is that it is desirable to finish the land most recently worked, in case the weather should change, and prevent the finishing of the grass seeds over the whole field.

Frost Injuring Clover Seeds.—Frost injures clover seeds, and will even kill them when exposed to it, so they cannot safely be sown very early in spring, nor left without harrowing. But they run little risk of damage from frost in March when harrowed in, which is best done with the grass-seed harrows, the roller of course following.

If rolling the grass seeds amongst the corn cannot be done at the time of sowing on account of the raw state of the land, it should be done as soon as the state of the ground will permit, as it is of vast importance to have a firm bed for the grass seeds and a smooth surface in reaping the crop.

GERMINATION OF SEEDS.

It will be interesting at this stage to contemplate the phenomena by which the seeds we have sown germinate and produce plants.

The healthy seed of a plant is a living object. Though apparently lifeless to the sight and touch, it possesses the germ of life, and its vitality is capable of exerting great force when excited into action. What excites the vitality of

seeds, we do not know, perhaps never shall—it is a secret which Nature has hitherto kept to herself; but we do know the circumstances in which seeds must be placed in order that they may begin to grow or germinate. The proof of the excitement is in their germination, which is the first movement towards the production of a plant.

Conditions essential for Germination.—Now, the circumstances which excite germination are the combined action of air, heat, and moisture. These must all be afforded in favourable conditions, before the seed will germinate and the plant grow satisfactorily. They may all be supplied to the seed, and its germination secured in the air as certainly as in the soil; but on the development of a root, most plants would die if kept constantly in the air. The soil supplies all the requisites of air, heat, and moisture to the seed in a better state than the atmosphere could alone; and it continues to supply them not only for the germination of the seed, but also for the support of the plant, during its entire life.

A vital seed placed in the soil is affected by three agencies—1, physical; 2, chemical; and 3, physiological—before it can produce a plant.

Air and Germination.—When a vital seed is placed in pulverised ground, it is *physically* surrounded with air; for although the particles of soil may seem to the eye to be close together, on examination it has been found that the interstices between the particles occupy about ¼ of a given volume of soil. Hence, 100 cubic inches of pulverised soil contain about 25 cubic inches of air. Therefore, in a field the soil of which has been ploughed and pulverised, and cleared of large stones, to the depth of 8 inches, 1 acre of it may contain about 12,545,280 cubic inches of air; and hence also, as every additional inch of depth pulverised calls into activity some 260 tons of soil, at 1.48 of specific gravity, so the ploughing up of another inch of soil not before stirred and not hitherto containing any air, introduces into the workable soil an addition of perhaps nearly 1½ million cubic inches of air. Thus, by increasing the depth of pulverised soil, we can provide a depot of air to any extent for the use of plants. It should be noted that it is the oxygen of the air that is of chief importance in germination.

But this air must be above a certain temperature ere the seed will germinate—it must be above the freezing-point, else the vitality of the seed will remain dormant. It is also desirable that the soil should be well pulverised, and not as in fig. 302, where a seed is placed

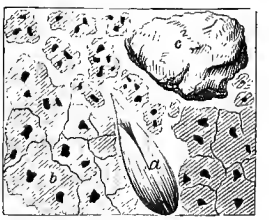


Fig. 302.—*Cloddy and stony soil.*
a The seed. *b* Hard clods. *c* A stone.

among hard clods on the one side, and near a stone on the other, conditions not likely to favour the development of strong regular plants.

Moisture and Germination.—Fig. 303 represents the seed placed in a pulverised soil, the interstices of which are entirely occupied by water instead of air,

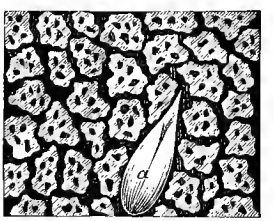


Fig. 303.—*Soil with water and without air.*
a The seed.
White spaces—pulverised soil. Black spaces—water.

as well as the interior of all the pulverised particles of it. It is clear that, in this case too, the seed, being deprived of air, is not placed in the most favourable circumstances for germination. Besides the direct exclusion of the air, the water, on evaporation, renders the earth around each seed much colder than it would otherwise be.

But total want of moisture prevents germination as much as excess. Fig. 304

shows the seed placed in pulverised soil, and the interstices filled with air, with no moisture present between or in the particles of soil. In such a state of soil,

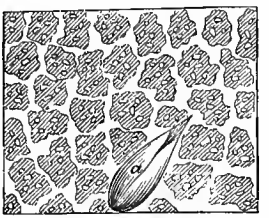


Fig. 304.—*Soil with air and without water.*
a The seed.
White spaces—air and heat.
Dark spaces—dry pulverised soil full of air.

heat will find an easy access to the seed, and as easy an escape from it.

Fig. 305 represents the seed in soil completely pulverised. Between every particle of the soil the air finds easy access to the seed, and in the heart of every particle of soil moisture is lodged. All that is here required in addition is a

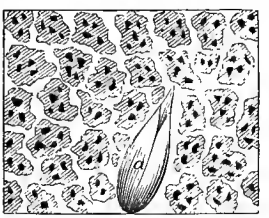


Fig. 305.—*Soil with water and with air.*
a The seed.
White spaces—air and heat.
Dark spaces—pulverised soil with darker water.

favourable temperature, which the season supplies, and germination proceeds.

Composition of Seeds.—The *chemical* composition of seeds consists of organic and inorganic substances. The organic are composed of 2 classes of substances, the nitrogenous and the non-nitrogenous; the inorganic, of earthy, alkaline, and acid ingredients. The nitrogenous substances consist of matter analogous to the caseine of milk, albumen of the egg and of blood, and of the fibrine of the flesh of animals; the non-nitrogenous consist of starch and mucilage, and of fatty and oily matters rich in carbon and hydrogen.

Changes incident to Germination.—When a seed is consigned to the ground, the first change which takes place in it is physical—it becomes increased in bulk by the absorption of moisture; and being also surrounded by air, it only requires the requisite degree of temperature to excite its vitality into action. If there is no moisture present, as in fig. 304, it will remain in a state of dormancy until moisture arrive, and in the meantime may become the prey of the many animals which inhabit the soil, eager for food, or be scorched to death by heat. If it is placed in excess of moisture, as in fig. 303, its germination is prevented by the exclusion of the air, and its tissues are destroyed by maceration in the water.

When the seed begins to germinate, a substance named *diastase* is formed at the expense of its albumen. The function of diastase is important. It is to convert the insoluble starch of the seed into soluble dextrine and sugar; to effect which change it seems to possess extraordinary power, as one part of diastase will convert into sugar no less than 2000 parts of starch. The diastase converts the starch which it finds into a useful state for the support of the first efforts of vegetation, and after having performed this important function, it disappears.

The Embryo.—"Under fitting circumstances," says Lindley, "the embryo which the seed contains swells, and bursts through its integuments; it then lengthens, first in a direction downwards, next in an upward direction, thus forming a centre or axis round which other parts are ultimately formed. No known power can overcome this tendency, on the part of the embryo, to elevate one portion in the air, and to bury the other in the earth; but it is an inherent property with which nature has endowed seeds, in order to ensure the young parts, when first called into life, each finding itself in the situation most suitable to its existence—that is to say, the root in the earth, the stem in the air."

The Young Plant.—When the germ has shot out from the seed, it is found to be possessed of a sweet taste, which is owing to the presence of grape-sugar in the sap which has already begun to circulate through its vessels. There is little doubt that the grape-sugar is formed sub-

sequently to the appearance of both diastase and acetic acid.[1]

Seed dissected.—A seed, considered *physiologically* in reference to its organisation, consists of an embryo, which includes the germs of the root and of the stem, and of a cotyledon or cotyledons. Fig. 306 represents a grain of wheat magnified, and so dissected as to show its component parts. It consists of two skins, an outer and an inner. The inner skin is also where the nutritive matters, called the starch and albumen, are situate. There is the little scale or cotyledon through which the nutritive matter passes in the sweet state, when the grain is germinating, and by which it is rendered most fit for the nourishment of the little plant; and there is the rudimentary plant, from the base of which roots or stems, or both, will afterwards proceed. All these parts are essential to the growth of the seed. If any one is absent the seed will fail to germinate.

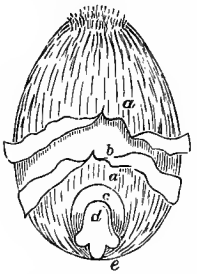


Fig. 306.—*Component parts of a grain of wheat.*
a a Outer skin.
b Inner skin.
c Scale or cotyledon.
d Rudimentary plant.
e Where nutritive matter, scale, and rudimentary plant unite.

Multiple Stems or "Tillering."—The seeds of most species of plants possess such a structure as that only 1 stem can proceed from them; but in many agricultural plants, particularly in the cereals, which yield human food, a remarkable departure from this structure is observed. In them the embryo plant is usually thickened towards its base, and is so organised that, instead of 1 stem, 3 or 4 may spring from 1 grain.

The peculiarity mentioned may be observed in fig. 307, where the rudimentary plant has 3 projections in the lower part, while in other kinds of seed there would have been only 1; and from each of these 3 projections a rootlet or a stem, or both, proceed when the grain is placed in the soil. The figure represents such a grain in a state of germination, one shoot having left the sheath, another just evolved, and a third remains unevolved, while the rootlets are seen extending downwards.

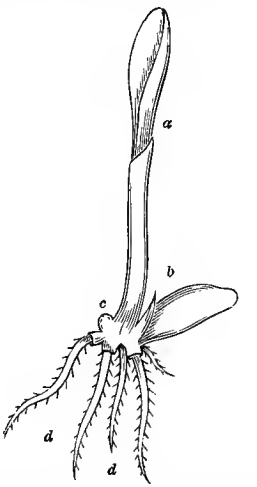


Fig. 307.—*Wheat plant in the state of germination.*
a Shoot leaving the sheath. *c* Shoot yet unevolved.
b Another shoot just evolved *d d* Rootlets.

Different Methods of Sowing and Germination.

Disadvantage of Broadcast Sowing.—Of all the modes of sowing seeds, none requires so much seed as the *broadcast.* However regularly the land may have been ploughed, seed sown broadcast will braird irregularly—some falling into the lowest part, some upon the highest, some scarcely covered with earth by the harrows, some buried as deep as the ruts of tines have penetrated. To make the land smooth by harrowing, previous to sowing the seed, would not cure irregular covering, since it is impossible to cover a large seed as that of the cereals with tines without the assistance of a rough surface of mould. In fig. 308 the furrows are well and regularly ploughed; but while

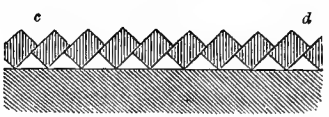


Fig. 308.—*Well-ploughed regular furrow-slices.*
c to *d* Regularly ploughed furrow-slices.

[1] Johnston's *Lect. Agric. Chem.*, 2d ed., 221-228.

it is obvious that the seeds, when scattered broadcast from the hand, will fall mostly in the hollows between the furrows, yet some will stick upon the points and sides of the furrow-slices. The seeds will thus lie in the ground, as in fig. 309, those which fell into the hollows of the furrows being thicker than the seeds which

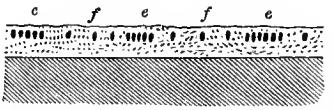


Fig. 309.—*Positions of seeds on regular furrows.*
e e e Seeds fallen in the hollows of the furrows.
f f Seeds scattered upon tops and sides of furrows.

stuck upon their tops and sides. But it is not at all likely that the seeds will be so regular as represented. Some will be too deep and others too shallow in the soil, whilst some will be left on the surface. From irregular deposition, plants will grow in irregular positions, as in fig. 310, where some are in clumps from the

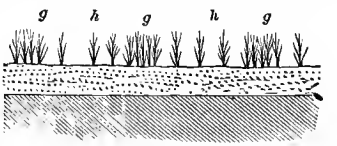


Fig. 310.—*Irregular braird upon regular furrows.*
g g g Plants growing in clumps.
h h Plants growing scattered.

bottom of the furrows, and others are straggling too far asunder. Where the seeds have been deposited at different depths, the plants will grow at more irregular heights than in the figure.

When the land is ill-ploughed, the case is still worse. Fig. 311 shows the irregular furrows from bad ploughing. Bad

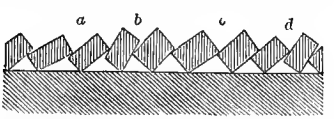


Fig. 311.—*Ill-ploughed irregular furrow-slices.*
a Furrow-slice too flat. *c* Furrow-slices too wide.
b Furrow-slice too high. *d* Furrow too deep.

ploughing entails bad consequences in any crop, but especially in cereal ones, inasmuch as irregularity of surface cannot be amended by a series of future operations, as in green crops. In the irregular furrow-slices of fig. 311, some are narrow and deep, some shallow, some too large, some of ordinary depth, and some too high and steep. The seed sown on these irregular furrows is shown in fig.

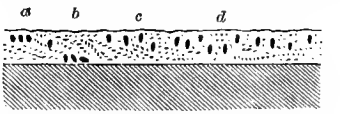


Fig. 312.—*Irregular positions of seed on ill-ploughed furrows.*
a Seed clustered and covered shallow.
b Seed clustered and buried deep.
c Seed scattered and covered shallow.
d Seed scattered and covered deep.

312, where some are clustered together with a shallow covering, others also clustered, but buried deeply, whilst many are scattered irregularly at different depths. Such a deposition of seed must make the braird come up irregularly; and the plants have not the chance of reaching maturity at the same time.

In fig. 313, where the seed was covered deeply, the plants will come up late;

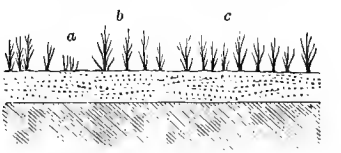


Fig. 313.—*Irregular braird on ill-ploughed furrow.*
a Late plants. *b* Early plants.
c Regular growth of plants.

with shallow covering, they will come up early, and will push on in growth; while the remainder, coming up regularly, will form the best part of the crop. Where a crop of cereals does not mature at the same time, the grain cannot be equal in the sample.

Advantages of Drill Sowing.—One obvious advantage of sowing with a *drill* over a *broadcast* machine, is the deposi-

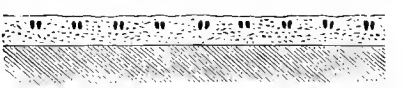


Fig. 314.—*Regular depth of seed by drill-sowing.*

tion of seed at the same depth, whatever depth may be chosen. Fig. 314 shows the seed deposited at regular intervals. The braird is shown at the same regular

intervals in fig. 315, and its produce will reasonably be of the same quality. For drill sowing the land has previously received all the harrowing it requires for the crop, and by the coulter or tongue of the machine the seed is deposited regularly at a uniform depth and thickness.

Still there are many who prefer broadcast sowing, and, with careful preparation

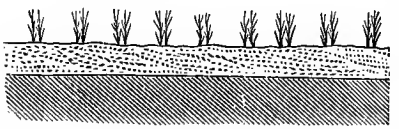


Fig. 315.—*Regular braird from drill-sown seed.*

of the seed-bed, and skilful performance of the work of sowing, it will usually give satisfactory results.

Drill sowing leaves a blank between the rows of plants, which encourages the growth of weeds. On the other hand, this system permits of hoeing after the plants are advanced considerably, and if this operation is carefully performed by hand or horse-hoe it is usually found to be beneficial to the crop.

Dibbling.—*Dibbling* is distributing seed by means of a dibble at given distances, and at a given depth in the soil. The distribution by this system may either be in rows or broadcast. The difference betwixt dibbling and drilling is, that in drilling the seed is placed in lines, while dibbling places it at uniform distances in the line. The object of dibbling is to fill the ground with plants with the smallest quantity of seed. The seed planted in lines with the dibble appears as in fig. 314, and the plants like those in fig. 315. The depth of the seed and brairding of the plants are as uniform as in drilling, but the plants stand independent of each other in dibbling.

As would be readily understood, dibbling is not suitable where any considerable extent has to be sown, but it is very useful in filling up blanks.

Waste of Seed.—When sown in all these ways in equal quantities, the *waste of seed*, as determined by experiment, is surprising. *Wheat* at 63 lb. the bushel gives 87 seeds to 1 drachm, avoirdupois weight, or 865,170 to 1 bushel. Now, 3 bushels of seed sown broadcast on the acre, gives a total of 2,595,510 seeds. Suppose that each seed produces 1 stem, and every stem bears 1 ear containing the ordinary number of 32 seeds, the produce of 1 acre would be 96 bushels. How far this exceeds the usual return need hardly be stated. Rarely, indeed, have we known the produce of wheat to exceed 64 bushels on 1 acre, so that in this case 32 bushels, or 33 per cent of the seed, would be lost, while in an ordinary crop of 40 bushels the loss of seed would be 58 per cent.

The waste in *barley* seed is estimated thus: Chevalier barley at 57 lb. the bushel, and 75 grains to 1 drachm, avoirdupois weight, gives 665,242 seeds; 4 bushels of seed sown on 1 acre, gives 2,660,968 seeds; and allowing 1 stem from each seed, and 1 ear of 32 seeds, the produce would be 128 bushels! Even with an exceptional crop of 64 bushels there would be a loss of 50 per cent, while on the ordinary crop of 48 bushels the loss would be nearly 69 per cent.

In like manner the loss upon *oats* may be estimated, and will be found to be often more than one-half the quantity of seed sown.

In all these cases only 1 stem from 1 seed is reckoned, but many of the seeds produce 2 or 3 or more. The *actual* loss of produce sustained is thus not so great as of seed.

Another view of the waste of seed is this: 2,595,510 seeds of wheat on 1 acre give 536 seeds to 1 square yard; 2,660,968 seeds of barley give 550 seeds; and 5,879,808 seeds of oats give 1214. In wheat and barley the proportion of seed is in proportion to their respective weights, but in oats the seed is more than double in proportion to the weight, because of the thick husk of the oats.

Waste of Seeds by different Methods of Sowing.—P. M'Lagan of Pumpherston made experiments to ascertain the waste of seed in sowing oats in the three different ways of dibbling, drilling, and broadcast. The oats weighed 42 lb. the bushel. The dibbled holes were made 6 inches apart, and 6 inches between the rows, making 36 holes in 1 square yard, and each hole was supplied with from 1 to 4 seeds, making the quantity sown from 1 peck to 4 pecks on 1 acre; and the seeds sown drilled and broadcast

were in the same proportion. In drilling and dibbling, the seed was inserted 3½ inches into the ground. The results were as follows:—

	Dibbled.	Drilled.	Broadcast.
From 36 grains sown	26 plants	32 plants	19 plants came up.
" 72 "	49 "	53 "	52 "
" 108 "	75 "	78 "	68 "
" 144 "	120 "	94 "	87 "
360	270	257	226
Percentage	.750	.714	.628

There is not much difference in the brairding of seed dibbled and drilled, which might have been expected, since the seeds were deposited much in the same position in the soil.

It is not easy to explain the disparity when so many as 144 seeds were sown, involving a loss of about 34 per cent.

The *broadcast* involves a loss beyond the others of 16⅔ per cent—an anticipated result, since many of the seeds were unburied on the surface, or buried too deeply. The seeds were sown on the 19th March, and the thickest sown of the drilled and broadcast brairded first on the 16th April. Thick-sown seeds always braird earliest.

The experiments were extended by sowing 7 pecks of oats drilled, or 252 seeds to the square yard, and from these 208 plants came up, giving a percentage of .825. There were also sowed 24 pecks to 1 acre broadcast, or 864 seeds to 1 square yard, which produced 570 plants, giving a percentage of .671, only a little more than in the former case of broadcast, .628. Thus, the smallest number of seeds gave the largest return of plants brairded.

G. W. Hay of Whiterigg, Roxburghshire, also made similar experiments at the same time, by dibbling and drilling wheat, barley, and oats, and sowing oats broadcast. The *dibbled* seeds were put into holes within 3 inches square to the number of 1, 3, and 6 grains in each hole, which gave respectively 144, 432, and 864 grains to the square yard. The seeds were sown on the 16th March, and the plants counted on the 8th May. The results were these:—

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of Wheat	97	296	616	1009 plants came up.
Barley	95	335	687	1117 "
Hopetoun oats	129	403	800	1332 "
Potato oats	135	407	823	1365 "
Birley oats	125	413	777	1315 "
Sheriff oats	132	405	751	1288 "
Percentage of				
Wheat came up	.67	.69	.71	average .69
Barley	.66	.79	.79	" .75
Oats	.90	.94	.91	" .92

On the 25th March similar seeds were sown in *drills* at the same rates per square yard, and the plants counted on the 8th May, when the results were:—

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of Wheat	105	327	652	1084 plants came up.
Barley	86	318	747	1151 "
Hopetoun oats	139	408	798	1345 "
Potato oats	137	407	795	1339 "
Percentage of				
Wheat came up	.73	.73	.75	average .74
Barley	.60	.73	.86	" .73
Oats	.96	.94	.92	" .94

On comparing the brairds of the drilled with the dibbled seeds in the barley and oats little difference is apparent, while the wheat incurs less loss of plants when drilled than when dibbled, in the ratio of 1009 to 1084. Comparing the results obtained by both experimenters, we find that Mr Hay obtained a braird of $^{9}/_{10}$ of the seed in dibbling and drilling; while Mr M'Lagan obtained only $^{7}/_{10}$, and, in oats broadcast, $^{6}/_{10}$.

Tillering.—After a lapse of ten days, on the 18th May, when rain had fallen in the interval, the plants after broadcast were counted, and were unexpectedly found greater in number than the seeds sown. The plants must have tillered after the rain, and the tillering was ascertained to be from :—

Seeds.		Plants.		Tillering.
315	Barley	360	=	one-sixth.
325	"	405	=	one-fourth.
471	Sherriff oats	930	=	double.
520	" "	648	=	one-fifth.
666	Potato "	704	=	one-sixteenth.

The advanced state of the plants after the rain indicates that in spring oats tiller very strongly and rapidly.

Quantity of Seed.—Taking the respective quantities of seed sown on 1 square yard by both experimenters, they will be as follows on 1 acre :—

Seeds.		Seeds.	Per acre.
36	per square yard =	174,240 =	1 peck.
72	" =	348,480 =	2 "
108	" =	522,720 =	3 "
144	" =	696,960 =	1 bushel.
288	" =	1,393,920 =	2 "
432	" =	2,090,880 =	3 "
576	" =	2,787,840 =	4 "
720	" =	3,484,800 =	5 "
864	" =	4,181,760 =	6 "

Produce from different Methods of Sowing.—Kenyon S. Parker made a comparative experiment between drilling, dibbling, and broadcasting wheat on clover lea, and the results show that drilling produced more grain than dibbling; while the straw was longer and stronger, the ears larger, and the seeds heavier in the dibbled, thus :—

	1 acre. bush.	peck.		1 acre. qr.	bush.	gal.	Weight per bush. lb.
Broadcast	1	3	produced	3	7	1	62
Drilled, at 12 in.	1	2	"	4	3	1	63
Dibbled	1	0	"	4	3	0	63½

Importance of economising Seed.—The questions to which such results give rise are, What quantity is too thick and what too thin sowing? and, What is the least quantity of seed to yield the largest crop? The inquiry assumes much importance when we consider that from $^{1}/_{10}$ to $^{1}/_{14}$ of all the grain grown in the country is every year put into the ground as seed. A small fraction of either of these proportions saved would add a profit to the farmer to that extent. If 1 bushel of seed could be saved on each acre, a simple calculation would show that the gain to the farmer would amount to a vast sum of money.

Thick and Thin Sowing.—Thick and thin sowing of seed is a subject of controversy among farmers. The saving of seed would be a sufficient argument in favour of *thin* sowing, provided the same return were received. But the results have been found to vary. There are many conditions to be considered in deciding as to the quantity of seed to be sown. The nature and condition of the soil, the climate, the quality of the seed itself, and even the character of the season, must all be kept in view.

Hewitt Davis, Spring Park, Croydon, who occupied 800 acres of high-rented poor soil, upon a warm subsoil of chalk, stated that "the practice throughout England is to sow 2 or 3 bushels of wheat to 1 acre, and the yield seldom reaches 40 bushels, and more commonly less than 20 bushels, so that $^{1}/_{10}$ at least of the crop grown is consumed as seed, whilst 1 single grain of wheat, planted where it has room to tiller out, will readily produce many 100-fold. The knowledge of these facts has induced me, in the course of years, to make a variety of experiments, the results of which have clearly shown me that, independent of the waste, a positive and serious injury of far more consequence is done to the crop from sowing so much seed. I bear in mind that, if so much be sown as to produce more plants than the space will allow to attain to maturity, the latter growth of the whole will be impeded, and a diseased state will commence as soon as the plants cover the ground, and continue till harvest." The quantities of seed Mr Davis determined on sowing, in accordance with these reasons, are, for—

Rye	1¼ bushel	sown in	August and September.
Winter barley	2 "	"	September.
Tares	1½ "	"	3 sowings in Aug., Sept., and Oct.
Oats	6 pecks	"	January, February, and March.
Barley	5 "	"	January, February, March, and April.
Wheat	3 "	"	September and October.
Peas	9 "	"	December, January, and February.
Beans	9 "	"	September and October.

The returns obtained by Mr Davis, after these scanty sowings, were 5 quarters of wheat, 13 quarters of oats, and 8 quarters of barley per acre on "very inferior land," from the manure available on the farm.[1]

Mr Barclay, Eastarch Farm, Surrey, *drilled* 2½ bushels of wheat at 9 inches apart, and obtained 37 bushels at 64¾ lb. per bushel, and 70 trusses of straw, value £16, 6s. He *dibbled* 1 bushel 3 pecks at 9 inches apart, and had 37 bushels at 64 lb. per bushel, and 72 trusses of straw, at a value of £15, 12s. 9d. He sowed *broadcast* 2½ bushels, and had 40 bushels at 65 lb. per bushel, and 84 trusses of straw, the value being £18, 1s. Here broadcast and thick sowing prevailed. Soil, deep loam on chalk subsoil.[2]

Mr Mechi, Triptree Hall, Essex, gave 4 pecks by Bentall's Dropper, and obtained 40 bushels of wheat. He gave 4 and 5 pecks on the same field by Bentall's Dropper and hand-dropping, and obtained 48 bushels of wheat. He gave 9 pecks by *drill* and *dibbles*, and obtained 32 bushels of wheat. "The quality of the wheat was good, weighing 63 and 64 lb. per bushel; the straw strong and bright. The straw was larger and longer, and the ears largest, when thin sown. I had only a ½ acre laid on 80 acres."[3] Here thin sowing prevailed.

W. Loft, Trusthorpe, Lincolnshire, *drilled* marigold wheat at 5 pecks, and obtained 56 bushels 3 pecks, at 63 lb. per bushel; and in the same field drilled 8 pecks, and they yielded rather more than 57 bushels per acre, at 63 lb. per bushel. "This result," W. Loft says, "is at variance with the opinions of the advocates of thin sowing as to quantity of seed; and indeed I do not believe that any specified quantity of seed can be laid down as the proper quantity for all descriptions of soil and climate—practice and experience alone must be the guide; for although I am willing to admit that wheat tillers well on this soil—loamy clay on tenacious clay subsoil—I find from repeated trials that it is not safe to sow much less than 8 pecks on an average. I now generally begin seed-time with 7 pecks as the minimum, gradually increasing, as the season advances, to 9 pecks."[4]

On the comparative merits of thick and thin sowing, it has been contended that experience has established that,—thick sowing is advisable on newly-broken-up land, containing a large amount of vegetable matter in an active state of decomposition, when it is beneficial in repressing, by its numerous roots and stems, that exuberance of growth which produces soft and succulent stems, which are easily lodged, and produce unfilled ears. Thin sowing has a tendency to make the roots descend deeply; and where a ferruginous subsoil exists, thick sowing keeps the roots nearer the surface, away from it. Thin sowing develops a large ear, grain, and stem, but delays maturity. Thick sowing on old land in high condition renders the plant diminutive, and hastens its maturity before the ear and grain have attained their proper size. Thin sowing in autumn affords room to plants to tiller and fill the ground in early spring, while thin sowing late in spring does not afford time to the plant to tiller. Thick sowing in autumn makes plants look best in winter, but gradually attenuates them in spring. Thin sowing makes plants look worst in winter, but to look better and fuller as the harvest approaches.

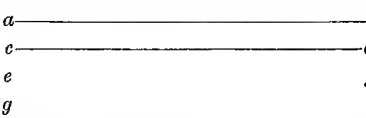
Different Methods of Sowing Compared. — On comparing the broadcast, drilled, and dibbled methods of sowing the cereal grains, it must be owned that the *broadcast* incurs a loss of seed by

[1] Davis's *Waste of Corn by Too Thick Sowing*, 6-12.
[2] *Jour. Eng. Agric. Soc.*, vi. 192.
[3] *Ibid.*, vii. 537.
[4] *Ibid.*, ix. 283.

some being exposed on the surface, and others sent too deeply into the soil. Such effects are produced whether by hand or machine sowing, and cannot be avoided until a machine is contrived to sow corn broadcast at a uniform depth.

The *drill* does not work well in stony ground, which easily jolts the coulters to one side, or they displace small stones, or ride over large ones; while where land-fast stones or subjacent rocks are near the surface, they would be broken. Where there are many stones the drill should not be used. Where the soil is fine, drilling has the advantage of having the land smooth before the seed is sown, and then seed escapes disturbance by cross-harrowing.

Dibbling may be done by a hand-dibble, or with an implement having pins attached to the bottom of a spar of wood, and which pins are thrust into the ground with a pressure of the foot. Another method is, to thrust small hand-dibbles through holes formed in a thin board of wood. In all these modes the seed is deposited in the holes at stated distances—perhaps 7 inches between the rows, 4 inches apart in the rows, and 2½ inches in depth. The earth is put over the holes with the foot. When a man uses a small dibbler, a convenient mode of keeping the lines straight is this: Take 2 long lines and stretch them along the side of the field, at a determinate distance between them; *a b* and *c d* are the 2 lines at a distance between them of *a c* and *b d*.



Let him dibble in the seed along *a b*, and when at *b*, let him shift that end of the line from *b* to *f*, and then dibble the seed in from *d* to *c*, where let him shift the end of the line at *a* to *e*, which brings the line straight from *f* to *e*. Before starting with the dibbling from *e*, let him remove the end of the line at *c* to *g*, and then dibble the seed from *e* to *f*, where he shifts the end of the line from *d* to *h*, which brings the line straight from *g* to *h*. Shifting the line from *f* to *i*, he proceeds as he did at *b*, and so on alternately from one side to the other.

Dibbling-machines. — The dibbling-machine first brought into notice was invented by James Wilmot Newberry, Hook Norton, Chipping Norton, Oxfordshire. It is ingenious and elaborate in construction, and deposits every kind of corn at given distances, in any quantity, with the utmost precision. Fig. 316 is a view in

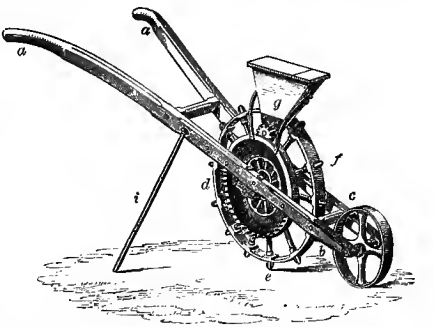


Fig. 316.—*Newberry's one-rowed dibbling-machine.*

a a Stilts.
b Fore part of stilts.
c Fore-wheel.
d Hollow flat disc.
e Projecting points or dibbles.
f Large outer ring.
g Hopper.
i Stay to support the machine.

perspective of a 1-rowed machine. It consists of a hollow flat disc, which contains the machinery that directs the corn from a hopper into hollow tubes, 18 of which are connected with and project from the circumference of the disc like the spokes of a wheel from its nave, and their points pass through a large outer ring, which retains the hollow tubes or distributors of corn in their respective places, and prevents them sinking into the ground beyond the requisite depth. A fore-wheel, which is placed between the extremities of the stilts or handles, prevents the large outer ring being pressed closer to the ground than needful. A man pulls the machine forward by means of a rope attached to the fore part of the stilts, or, what is better, a bridle and shackle might be mounted there, for yoking a pony or horse to draw the machine. As the wheel is drawn forward by the horse, it turns round by contact with the ground, the projecting points of the hollow tubes acting as dibbles and making holes in the ground; a portion of the dibbles, before leaving the ground, slides up upon the upper part, making an opening through which the corn is deposited in the holes. The corn descends of the

requisite number from the hopper by means of feeding-rollers, moved by a pinion, which is set in motion by teeth placed on the circumference of the flat disc. The disc is supported in its centre by an axle revolving in its ends on plummer-blocks. In using this machine, a man holds by the two stilts, while a man or horse draws the machine in the given line. The line not being in the line of the body of the drill, a rigger is required for the horse to be yoked to. A stay supports the machine when at rest. This 1-rowed dibble is said to be well suited for sowing mangel seed on the top of the drill.

Another dibbling-machine, presented to public notice by Samuel Newington, of Knole Park, Frant, Kent, is shown in fig. 317—a view in perspective of one

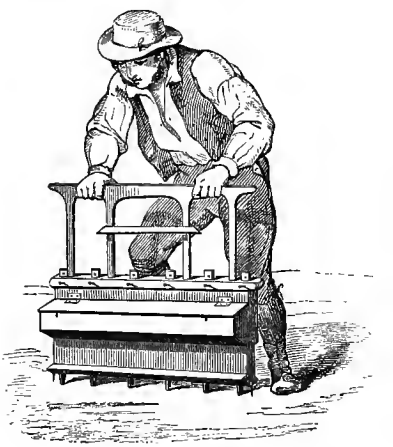


Fig. 317.—*Newington's 6-rowed dibbling-machine.*

having 6 depositors. The box in front contains the corn, and the points of the depositors are seen to rest upon the ground, which has been harrowed smooth for the purpose. The depositors place the seeds at the desired depths, deeper or shallower, being kept in their places by pinching screws. The machine is worked by taking hold of the upper rail by both hands, and, on pressing upon it, the depositors, when withdrawn, leave the requisite number of seeds in each hole the depositors have made, by the machinery in the interior of the machine. By pressing down the upper handle, the depositors press every seed firmly into a solid bed, which is so small as to preclude the fear of its containing water, and yet completely buries the seed. By changing the cups, the quantity of the corn is regulated, as well as the description of corn. With a machine having 6 depositors, 1 man can dibble 1 acre in 10 hours, so that the cost of dibbling may be easily ascertained by the rate of wages in the district.

In using the machine after the first line is laid off straight next the fence, the workman continues to keep the other lines straight at the stated distance by the mark left on the ground by the machine. The seeds are put in at 4 inches apart in the rows, and the quantity is varied by either altering the distance between the rows, or increasing the number of seeds in each hole, but it is not desirable to exceed 3 seeds in 1 hole. The cups which contain the grains are of 4 sizes, and can be easily removed or replaced by means of screws.

As already indicated, dibbling is too slow a process for the modern necessities of farm practice, but on a small scale, and for filling up blanks, it may be pursued with advantage.

Deep and Shallow Sowing.—Another circumstance which affects the relation between the grains sown and the plants produced, is the *depth* to which the corn is buried in the ground. In ill-ploughed land, when the corn is sown broadcast, falling between ill-assorted furrows, some of it may sink to the bottom of the furrow-slice, where it will be buried, to become dormant or lose its vitality. Corn is differently affected by depth in soil, some sorts germinating at a considerable depth, whilst others become dormant or die if placed at a smaller depth below the surface of the ground. A stem of barley has been traced to a depth of 9 inches, while oat seed buried 7 inches cannot be depended on to germinate. This accounts for oats which had slipped to the bottom of the furrow-slices of lea and perished. The risk of thus losing seed in fresh-ploughed lea induces us to recommend partial harrowing of ploughed old lea before the seed is sown.

Wheat possesses a peculiarity in the growth of the root. The grain will

bear to be deep-sown — not so deep as barley, but deeper than oats. Most wheat seeds may germinate at a depth of 6 or 7 inches, but sowing at that depth is risky, for the crop will likely be thin. After the germ of wheat has become a stem, it puts out another set of roots about 1 inch below the surface. The deeper may be called the *seminal*, and the upper the *coronal* root of the wheat plant. Fig. 318 shows the position of the roots under the surface, where *a* is the seed with its seminal roots *c*, and the germ *b* rising from it to the surface of the ground at *f*, above which is the stem, with its leaves. About 1 inch below the surface *f*, at *d*, are formed the coronal roots, *e e*, the office of which is to form the site from which the tillers are sent forth. At whatever depth the seed may have been sown, the coronal roots are formed at 1 inch below the surface.

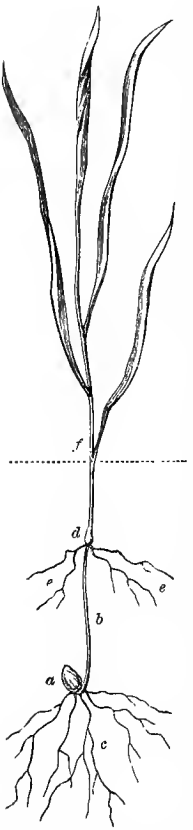


Fig. 318.—*Double roots of deep-sown wheat.*

"As the increase and fructification of the plant depends upon the vigorous absorption of the coronal roots, it is no wonder that they should find themselves so near the surface where the soil is always the richest. I believe I do not err when I call this *vegetable instinct*. In the N. counties wheat is generally sown late. When the frost comes, the *coronal* roots, being young, are frequently chilled. This inconvenience may, however, be easily prevented by sowing more early, and burying the seed deeper. The seminal roots, being out of the reach of frost, will then be enabled to send up nourishment to the crown by means of the pipe of communication."

Now the form which the plant assumes, when sown near the surface, is different, as in fig. 319, where *a* is the seed with its seminal roots; *b* the pipe of communication between them and the coronal roots *c c*, a little beneath the surface *d*. The coronal root *c* being at a short distance from the surface, the pipe of communication is shortened to the smallest degree. "Hence it is obvious," continues the same writer, "that wheat sown superficially must be exposed to the frost, from the shortness of the pipe of communication placing the seminal root within reach of the frost. The plant, in that situation, has no benefit from its double root. On the contrary, when the grain has been properly covered, it depends almost entirely on the coronal roots, which, if well nourished during the winter, will send up numerous stalks in spring; and on the tillering of the corn the goodness of the crop principally depends; but if not well nourished there will be no tillering. A field of wheat dibbled, or sown in equidistant rows by the drill, always makes a better appearance than one sown with the harrow. In the one the pipe of communication is regularly of the same length, but in the other it is irregular, being either too long or too short."[1] The conclusions these statements would warrant in practice are: That wheat sown before winter should be deeply covered with earth, to be beyond the reach of ordinary frost; that in spring the coronal roots will set up abundance of tillers or stools; that wheat sown in spring should be lightly covered, the tillers being few; that autumn wheat should be drilled to secure the pipes of communication be-

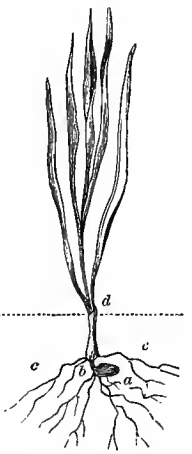


Fig. 319.—*Roots of shallow-sown wheat.*

[1] *Georgic. Ess.*, i. 67-69.

tween the seminal and coronal roots being long and uniform; that spring wheat should be sown broadcast; and that autumnal wheat should have a smaller quantity of seed than spring wheat.

Depth for Grass Seeds.—Depth of sowing affects no plants so sensibly as the grasses. Some experiments were made at Glenbervie, Falkirk, to ascertain the depth which the common grass and clover seeds should be covered, to produce the greatest number of plants. The same weight of seed was sown of each kind, and as different seeds differ in bulk and weight, the numbers of each kind differed materially. A better plan would have been to have sown the same number of seeds of each kind whatever their weight, and the proportion which came up of the plants would have been more easily ascertained than by the method adopted. Each kind of seed was covered from ¼ of an inch to 3 inches of depth in the soil. They were sown on the 1st of July, and counted on the 1st of August, and the results are shown in the following table:—

KINDS OF SEED EXPERIMENTED ON.	No. of seeds sown altogether.	COVERED AT ¼ in.	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	1¾ in.	2 in.	2¼ in.	2½ in.	2¾ in.	3 in.	No. of plants that came up.	Proportion of plants that came up.
Perennial ryegrass (*Lolium perenne*)	348	29	30	27	19	16	19	14	21	11	9	8	4	198	.57
Italian ryegrass (*Lolium Italicum*)	276	24	21	20	13	13	10	11	8	9	6	5	5	145	.51
Cocksfoot (*Dactylus glomerata*)	300	30	22	15	15	10	9	7	5	2	..	..	..	115	.38
Large fescue (*Festuca elatior*)	312	20	24	20	16	13	13	11	9	4	2	1	..	142	.42
Meadow fescue (*Festuca pratensis*)	324	28	28	16	12	10	6	9	4	2	2	..	..	117	.36
Varied-leaved fescue (*Festuca heterophylla*)	348	31	23	20	18	12	9	6	4	1		..	..	124	.35
Hard fescue (*Festuca duriuscula*)	300	30	23	10	15	10	8	5	3	1		..	..	114	.38
Meadow foxtail (*Alopecurus pratensis*)	192	17	17	16	15	12	7	6	3	1		..	..	94	.49
Timothy grass or meadow cat's-tail (*Phleum pratense major*)	528	52	39	37	19	16	15	7	5	..	..	..	..	190	.36
Evergreen wood meadow-grass (*Poa nemoralis sempervirens*)	228	24	14	4	1	..	..	..		..	..		..	43	.18
Rib-grass (*Plantago lanceolata*)	252	22	25	19	17	14	11	10	8	6	2		..	134	.53
Red clover (*Trifolium pratense*)	192	17	16	14	11	11	8	4	4	..	..	..		85	.44
White clover (*Trifolium ripens*)	144	13	11	6	4	3	1	..	.	..	..	..		38	.26
Yellow clover (*Medicago lupulina*)[1]	96	12	10	8	6	4	2	..	..	..	..	..	..	42	.43
	3840	349	303	232	181	144	118	90	74	37	21	14	9	1581	.46

In only 3 cases did the number of plants exceed ½ the seeds sown, those being perennial and Italian ryegrass and large fescue—the average of the whole being under ½—viz., .46. The clovers came up in small proportion, particularly the white, which is considered a hardy plant in this climate. Of the depths, the ¼-inch covering gave the largest return of plants, and 16 per cent more than ½ inch.

Mr John Speir, Newton Farm, Newton, Glasgow, states that, in a series of trials with grass and clover seeds sown at different depths up to 1½ inch, he obtained results which do not agree with these recorded at Glenbervie. Mr Speir remarks that his experience does not favour so shallow a covering as is likely to be got by first rolling, then sowing, then harrowing with a light-toothed or chain harrow, and finally rolling. He is thus opposed to rolling prior to sowing grass seeds.

In such soil as prevails on Mr Speir's farm, which is not difficult to reduce to a fine tilth, there will rarely be any necessity for rolling before sowing. Rolling is unquestionably beneficial when by the harrows a fine smooth surface cannot be prepared for the grass seeds. If chain or light-toothed grass-seed harrows will not provide a sufficiently deep covering for the seeds after rolling, then ranker-toothed harrows may be used. The object aimed at in using the roller before sowing is to secure for the small seeds a firm level bed, where their regular germination will not be interfered with by clods and heights and hollows. Where

[1] *Trans. High. Agric. Soc.*, Jan. 1845, 341.

this can be obtained without prior rolling, there is no need to occupy time with this operation.

Depth of Sowing Turnip-seeds.—The author of this work made an experiment on turnip-seeds, to ascertain the effects of deep sowing in comparison with shallow in the most favourable circumstances for vegetation — a loose soil in the temperature of 75° in a vinery. Seeds of swedes, yellow Aberdeen, and white globe turnips were sown, 40 of each, in friable soil taken from under fine old pasture, at 1, 2, 3, and 4 inches in depth in pots, and the plants which came up in time and in numbers were :—

	Inches in depth.	Plants came up.	In days	In hrs.	In proportion.
	Swedes.				
From 40 seeds,	1	31	4	12	.77
"	2	29	5	18	.72
"	3	20	6	21	.50
"	4	10	8	18	.25
	Yellow Aberdeen.				
"	1	28	4	10	.70
"	2	25	4	18	.62
"	3	14	5	13	.35
"	4	5	8	14	.12
	White globe.				
"	1	22	4	10	.55
"	2	18	4	13	.45
"	3	12	7	0	.30
"	4	7	7	13	.17

On comparing these results, the large proportion of plants coming from seeds at 1 and 2 inches in depth, compared with 3 and 4 inches, is very apparent; while there is not much difference between 1 and 2 inches in depth. The proportion that came up at 4 inches was so small, it is possible that had the experiments been made in the open air, no plants would have come up at all, since those which did come were puny. Of the seeds the swedes gave the most vigorous plants, the white globe the weakest, though the yellow Aberdeen showed more weakness in penetrating 4 inches than the globe. The conclusions drawn are, that no turnip-seed should be sown deeper than 2 inches. In many cases the coulters of sowing-machines place turnip-seeds too deeply in the soil.

Tillering.—The property of the cereal plants to *tiller* or *stool*—that is, to send up a number of stems from the same root—is a valuable one in an economical point of view. But for this property, when the seeds of the cereals happen to be destroyed by insects under ground, or by the unfavourable state of the ground or air for vegetation, or from the destructive effects of frost, or when young plants are injured by insects as they appear above the surface, the crop would be so scanty that it would be ploughed up by the farmer, and another substituted in its stead. The extent of tillering depends in some circumstances on the state of the soil and weather, and the space allowed the plant to spread in. A loose soil, admitting the shoots of the radicles to penetrate easily, encourages tillering more than a stiff hard soil. Yet wheat tillers best on a moderately firm clay soil in good heart. The weather when moist and warm promotes tillering.

Unless plants have space for their roots, they will not tiller. Tillering implies an instinctive faculty in plants to search for as much food as they can, and this is strikingly exemplified in the stronger or tillering plants overcoming and killing the weaker.

The question which such an occurrence gives rise to is, Whether it is better to allow few plants to fill the ground by tillering, or to fill the ground at once with the requisite number of plants? The answer to this question must be given conditionally. In naturally fertile soils, and in those rendered fertile by art, tillering will take place, and should be encouraged, inasmuch as the straw and ears of tillered plants are much stronger and larger than those of single plants. In such conditions of soil, a small quantity of seed will suffice in early spring, and it is in that season that tillering takes place in a sensible degree; but the seed must not be sown so deeply nor so late as to deprive the plant of time for tillering, so as to occupy the ground fully.

The extent of tillering is sometimes remarkable. Le Couteur mentions a downy variety of wheat which tillers to the extent of 32 plants,[1] and from 5 to 10 stems are a common tillering for ordinary varieties of wheat. Barley also

[1] Le Couteur's *Wheat Plant*, 29.

tillers, though late and thick sowing, with quick growth, overcomes that tendency. Oats indicate fully as strong a tendency to tiller as wheat. In weak soils, and soils in low condition, the tendency to tiller is much checked, each single root being conscious of its inability to support more than its single stem. Hence the practice is to sow more seed in low than in high conditioned land, and yet the ability to support the larger number of plants is in an inverse ratio. Yet what can the farmer do but sow as many seeds as will produce as many plants as will occupy the soil? The best way for him to escape from the dilemma is to put the soil in high condition, and reap the advantages derivable from tillering.

Destruction of Seed.—The great loss in plants compared with the numbers of seed sown may be accounted for from natural causes. Birds pick up seeds exposed on the surface after broadcast sowing. Many vermin, such as the rabbit, devour the young germ as it penetrates the soil, and many insects subsist on the stems and roots of young plants.

Transplanting.—A mode of saving seed to a greater degree than by dibbling and drilling, is by *transplantation*. This is done by sowing a small portion of ground with seed early in the season, taking up the plants as they grow, dividing them into single plants, and transplanting them. By thus dividing the plants as they tiller into single plants, at four periods of the season, a very small quantity of seed will supply as many plants as would cover a large extent of ground. Though wheat no doubt bears transplanting, yet the amount of manual labour which the scheme would entail would be so great as to render it impracticable upon any considerable scale.

This method, however, has been pursued with a certain measure of success in the formation of permanent pastures.

When it is desired to propagate a new variety of grain quickly, this process of transplanting might perhaps be useful. It may therefore be interesting to preserve the following record of the details and costs of the operation: Suppose 440 grains of wheat are sown widely on the 1st of July, and that every seed germinates by the beginning of August, each seed will afford four plants, or in all,

1,760 plants

At the end of August these will produce 5,280 "
In September these again 14,080 "
And in November these last will produce . 21,120 "

The time occupied in sowing the 440 grains, and dividing and transplanting their produce, stands thus:—

				Hours.	min.
July sowing,	. . .	440	grains,	0	20
August, beginning,	taking up .	440	plants,	0	20
"	dividing into .	1,760	"	1	10
"	planting.	1,760	"	3	30
August, end,	taking up .	1,760	"	1	28
"	dividing into .	5,280	"	3	30
"	planting. .	5,280	"	10	33
September,	taking up .	5,280	"	4	24
"	dividing into .	14,080	"	9	23
"	planting. .	14,080	"	28	9
November,	taking up .	14,080	"	11	44
"	dividing into .	21,120	"	14	4
"	planting. .	21,120	"	42	14
				130	49

Equal to 13 days 49 minutes' work at 10 hours a-day. Of these 13 days, 5 days may be reckoned for women and boys occupied in taking up and dividing the plants, which, at 1s. 6d. per day, will cost 7s. 6d. The remaining 8 days are for men transplanting, at 14s. per week, which will cost 18s. 8d. more; both 26s. 2d. per acre. The seed for the plants, ½ bushel at 48s. the quarter, or 6s. the bushel, would cost 3s. The entire cost would be £1, 9s. 2d. The saving of seed from the ordinary quantity sown would be the difference of cost between ½ bushel and 3 bushels, 15s. So that the loss on the transplanting over sowing would be 14s. 2d. Of course the cost of transplanting would vary with the rate of wages.

The best way of executing this plan is to dibble in the seed two grains in a hole, about 4 inches from each other, the plants to be taken up when in a proper state, and divided into five, which would be as many at that time as could be had, and then planted out at once, where they are to remain, thus getting rid of all the intermediate dividings.

FORAGE CROPS.

Forage crops may be defined as those which are grown for the sake of their

leaves and stems, as distinct from crops grown for seeds and roots. Chief amongst the forage crops are the grasses and clovers. These have already been described, and here will be given some information regarding several other forage crops which may be grown to provide wholesome green food for farm live stock. These are vetches, lucerne, sainfoin, rye, cabbages, rape, mustard, kidney-vetch, gorse or whin, buckwheat, maize, sorghum, and prickly comfrey. Sainfoin, lucerne, buckwheat, maize, and sorghum are confined to southern parts, where the climate is mild; the others may be grown in almost any part of the kingdom.

Importance of Forage Crops.—The growing of forage crops, particularly of crops to be cut and used as green food, has not yet received from British farmers so much attention as it deserves. Our acquaintance with forage crops is still very imperfect, and the extent to which they are capable of contributing to the saleable produce of the farm is not fully understood or appreciated. Providing a plentiful supply of green succulent food coming into use in succession all through the year is one of the greatest objects of the stock-owner. The forage crops at present in use, as they are now known and cultivated, are far from adequate for this purpose, and assuredly no subject could more worthily engage the attention or employ the resources of our great agricultural and experimental bodies than furnishing to farmers the knowledge and the means which would enable them to grow a more abundant supply of green food for stock throughout the year.

Forage Crops as Substitutes for Turnips.—In a very useful paper upon this subject in the 'Journal of the Royal Agricultural Society of England' (vol. xxv. part I., 1889), Mr Joseph Darby writes:—

"Cabbages, thousand-headed kale, and kohl-rabi may be made use of as substitutes for turnips and swedes as well as mangels, and the cost of growing kale and kohl is not usually considered to be more than that for swedes. Further, while requiring less manure than mangels, they are equally sure in succeeding well. Farmers who find it difficult to rely on turnip crops can also fall back on vetches, trifolium, rye, and winter oats, which, when autumn-sown, occupy the land at a period when it would probably otherwise be either fallow or growing weeds. These crops, if cut for green fodder just when they have attained their maximum growth, might be converted into silage, and the soil be still available for growing swede and turnip crops the same year. There appears to be great gain, from several points of view, in taking this course, and no doubt it has been adopted largely since the ensilage system was introduced some four or five years since. In the first place, the tillage expenses need not be increased, and on tolerably clean land there would be many less weeds by two croppings taking place instead of one. In nearly all cases where land intended for swedes and turnips is kept idle throughout winter and spring, three, and sometimes four, ploughings are given, the amount of additional cleaning being very great indeed.

Forage Crops for Heavy Land.—"The assertion has often been made that catch crops can only be advantageously grown when the land is perfectly clean as well as in a good state of fertility; but, in the course of correspondence with practical farmers on the subject of this paper, I have been informed by a gentleman of great skill and excellent judgment that he considers it by far the most economical and remunerative course on all heavy or medium soils to sow vetches in the autumn if the stubbles are foul, to ensile the crop in June, and give the land fallow working for six weeks, then to take a crop of mustard, to be sown about the last week in August, for sheep feeding or for a second silage crop, as may be most convenient.

"Many cases could be mentioned of the heavy Weald clay district of East Sussex, and a portion of Surrey, having been greatly benefited by the introduction of the ensilage system. On the farm of Major Cazalet, near Dorking, 300 acres being arable, no roots whatever are grown, some 400 tons of green fodder affording sufficient silage for them to be dispensed with. Lieut.-Colonel Coussmaker, at Westwood, Guildford, in cropping 112 acres of arable, depends on mangels and thousand-headed kale, by

appropriating 5½ acres to each, which, with 3 acres to cabbages and carrots, and about 15 acres of trifolium and vetches, and a still larger area to Italian rye-grass for silage, make up his winter supply of succulent food, unless able to grow some swedes and turnip after the catch crops. On Mr R. Whitehead's farm, at Old Paddockhurst, nearly 500 cattle and 400 sheep, besides horses, are wintered chiefly on silage, the manager, Mr Abbott, giving it as his opinion that from 10 to 12 tons of silage per acre can be obtained at less than half the cost the growth of any kind of roots would entail on this kind of land."

Vetches.

The vetch or tare belongs to the natural order of *Leguminosæ*, and the cultivated tare or vetch is named *Vicia sativa*. In the wild state it is a native of Europe, in corn or cultivated fields; plentiful in Britain; also in North America, about Fort Vancouver. Flower purple. This is a very variable plant in the form of its leaflets, in the size of the stems, and in the colour and size of the seeds. The *Vicia narbonensis*, Narbonne vetch, and the *Vicia serratifolia*, serrate-leafleted vetch, are cultivated on the Continent. Anderson has recommended the culture of the *Vicia sepium*, hedge-vetch; and a writer in the Bath papers advocates that of the *Vicia cracca*, tufted vetch. These are eminently beautiful native plants, but too tiny in the leaf and attenuated in the stem to make them worthy of cultivation. There are 108 described species of *Vicia*—a name said to be derived from *vincio*, to bind together, because the species have tendrils by which they bind themselves to other plants. The Romans took care not to sow tares in dew or moisture, the period of the day being some hours after sunrise, and no more was sown than could be covered up before night.

The vetch is a most valuable forage crop. It is hardy and prolific, and affords palatable and wholesome food for stock. There are two varieties, the winter and the spring vetch. The former, through repeated sowing in winter, has acquired a hardiness that is quite remarkable.

Winter Vetches.—The winter vetch is often sown along with rye or oats, to provide green food in spring before a full supply of grass is available. Sown before the winter frosts set in, usually during September or October, this crop will generally afford a good cutting from the second week in May till end of June in northern parts, and still earlier in warmer counties. Vetches are often consumed on the land by sheep, this practice being confined mainly to southern counties. The importance of having a supply of fresh succulent food at this season of the year, when roots are wholly or nearly exhausted, and before the pasture fields can sustain the animals, will be readily acknowledged by all farmers, and it is surprising that winter vetches are not sown much more extensively than they are, especially when it is remembered that they are off the ground in time for a root or potato crop in the following season.

Spring Vetches.—Vetches should be sown at different times in spring, so as to afford a succession of cuttings when green food is likely to be most urgently required. If the weather and the state of the land permit, the first sowing may be made in February, and successive sowings may take place every second or third week up till towards the end of June. It is advisable to sow small breadths at a time, so as to have a succession of cuttings when the crop is in full bloom. By judicious sowings at different times in autumn, winter, and spring, supplies of fresh-cut tares may be had from the end of April till October.

Information as to the feeding value of vetches, with analysis of vetches *made into hay*, is given in pp. 276 and 377, vol. i.

Use of Vetches.—The value of vetches as a forage crop for supplying green food in summer and early autumn is not sufficiently recognised. Where, from drought or other causes, there is likely to be a scarcity of food for stock in summer or autumn, a few successive sowings of spring vetches will come in very opportunely. Then, in carrying stock from the grazing season to the winter rations, vetches will also be found most valuable.

Vetches for Horses. — Horses eat vetches with a keen relish, and thrive well upon them. They should be provided for horses during the harvest work, and given in moderate quantities along

with dry food. It is considered by many that on strong land there is no better or cheaper way of keeping farm-horses in summer than by feeding them in the stable or yards with vetches and a little dry food.

Land for Vetches.—Vetches usually follow a grain crop. They thrive best on strong loams and tenacious clays, just the sorts of soil upon which turnip culture is most difficult. But they also afford a good return on lighter soils. In some cases vetches are sown upon strong land, which is fallowed in summer as a preparation for wheat. In other cases turnips or potatoes succeed winter vetches, so that the latter come in as a sort of "catch crop"—and a most useful one it is.

Seed.—The seed of vetches is usually sown broadcast, but often in rows about 8 inches apart. The quantity of seed varies from 2½ to 3½ bushels per acre. The seed is harrowed in the same way as a corn crop. In many cases, a little rye or oats is mixed with the vetches. The grain helps to support the pliant bine of the vetch. About 2 bushels of vetches to 1 of oats or rye per acre would be sufficient seed.

Cutting Vetches.—Vetches are most valuable for feeding when cut just in full bloom, and before the seed has begun to form. It is thus important to sow small quantities at a time, so as to be able to use the crop as it comes into bloom. When vetches are grown for seed they are, of course, allowed to ripen, and are cut and harvested in the same way as peas.

Manuring Vetches. — Land for vetches may be easily and cheaply manured. Mr John Speir says: "If the land is in moderately good condition, it may receive a light dressing of farmyard manure, which it is preferable to let lie on the surface for a few weeks previous to ploughing in. Along with the dung, or at any suitable time before it or after it, 3 or 4 cwt. of kainit should be sown over the unploughed land, and the same or more on the surface, as soon as the land is ploughed and before it is harrowed." [1]

Vetches and cleaning Land.—"With such a system of manuring, vetches seldom fail to do well with any sort of moderate season, and with a full crop they smother root-weeds well out, and owing to the early cutting of the crop, seed-weeds have no time to ripen their seeds. The land being bare comparatively early may be bastard fallowed, cleaned, and sown with wheat or other winter growing crop. Vetches, therefore, if well done to, offer an excellent opportunity of keeping down weeds, and of cleaning the land after the removal of the crop, thus leaving it in good condition for what is to follow." [2]

[1] *Farming World Year-Book*, 1889.

Lucerne.

In warm climates, notably in the southern counties of England, lucerne is a prolific forage crop. It is the *Medicago sativa* of botanists (Nat. Order *Leguminosæ*); roots sub-fusiform, stem erect, flowers large and violet-coloured. Its name is derived from that given by Dioscorides to Median grass. Lucerne is said to have been brought to Greece from Asia. The Romans were well acquainted with its properties as a forage plant, particularly for horses. Hartlib endeavoured to introduce its culture into England in the time of the Commonwealth, but did not succeed. It is cultivated in many parts of Europe in the field; but "it is very remarkable that this species of forage, to which so much importance was attached by the Romans, has altogether disappeared from Italy. We are assured by M. Chateauvieux that not a single plant of it is now to be seen." [3]

When well laid down in suitable soil —deep calcareous loam, clean and in good heart—lucerne affords several cuttings every year of excellent green food, which is relished by both cattle and horses. If kept free from weeds, the crop may remain productive for six or seven years. Weeds, however, are liable to disturb it, and may cause it to be ploughed up earlier. Land should therefore be prepared with great care for lucerne. It should be well cultivated, and as thoroughly as possible cleared of weeds of all kinds. Occasionally the year's produce amounts to 30 tons per acre, and 20 tons are by no means rare.

[2] *Ibid.*

[3] *Dict. Gr. Rom. Anti.*—art. "Agricultura." New edit.

The seed is sown in April, in rows 10 or 12 inches apart, at the rate of 10 to 20 lb. per acre. One cutting will be obtained in the autumn of the same year, but it is advisable to leave a rank growth to protect the roots from the winter's frosts.

The Crop for Dry Seasons.—Lucerne withstands drought wonderfully. It thrives best in a dry climate, and is therefore cultivated extensively on the continent of Europe. It is an exceptionally deep-rooted plant, and is thus comparatively independent of rain. Sir John Bennett Lawes has found it the best of all the forage crops for a drought.

Lucerne is not suited for extended cultivation in our moist climate. Professor Wrightson remarks that, as a special crop for odd corners, it is well enough, but that as a competitor with our established fodder crops, it is nowhere.

Sainfoin.

Upon the calcareous soils of the southern counties of England, sainfoin has proved a most useful and reliable forage crop. Belonging to the Natural Order *Leguminosæ*, it is the *Onobrychis sativa*, the cultivated sainfoin of botanists; roots sub-fusiform, stems erect, flowers in spikes or long foot-stalks, of a beautiful pink or flesh colour. Its generic name is derived from the Greek, signifying plants grateful to the ass; its ordinary name is evidently from the French, meaning consecrated hay—from its property of producing an excellent hay.

Sainfoin Hay.—The sainfoin yields by much the finest quality of hay when cut before the blossom comes out. "This hay, so cut before blossoming," says Jethro Tull, "has kept a team of working store-horses, round the year, fat without corn, and when tried with beans and oats, mixed with chaff, refused it for the hay. The same fatted some sheep in the winter in a pen, with only it and water; they throve faster than other sheep at the same time fed with peas and oats. The hay was weighed to them, and the clear profit amounted to £4 per ton. They made no waste, though the stalks were of extraordinary bigness; they would break off short, being very brittle. This grew on rich land in Oxfordshire. The second sort of sainfoin hay is cut in the flower; and though much inferior to the virgin hay, it far exceeds any other kind as yet commonly propagated in England; and if it be a full crop by good culture, may amount to above 3 tons on an acre. This is that sainfoin which is commonly made, and the larger it is the more nourishing for horses. I have known farmers, after full experience, go three miles to fetch the largest stalky sainfoin, when they could have bought the small, fine, leafy sort at home, for the same price, by the ton. The next and last sort of sainfoin that is cut only for hay is the full-grown, the blossoms being gone or going off: this also is good hay, though it falls short, by many degrees, of the other two sorts. It makes a greater crop than either of them, because it grows to its full bulk, and shrinks little in drying."[1]

Sainfoin, like lucerne, is a deep-rooted plant, and thrives best on dry soils in a dry warm climate. It is grown extensively, and with great success, on the chalky soils of the southern counties of England. It is useful as an ingredient in mixtures for temporary grass and hay, but is perhaps still more valuable as a forage crop grown by itself.

If well laid down in clean suitable land, it will endure, and yield liberally for six or seven years. It should not be resown upon the same land for some twenty or more years. Indeed it is a common saying that land will not successfully carry sainfoin more than once in a lifetime. Sainfoin is both cut and pastured, and especially for sheep a run of old sainfoin is much esteemed.

It is not a reliable crop on strong lands or in wet climates.

Land intended for sainfoin should be thoroughly clean and in good heart. The seed is best sown with barley or oats, and it may be mixed and drilled with the grain seed. In other cases it is drilled separately at the same time across the rows of the grain seed. The quantity of sainfoin seed used per acre is usually about four bushels of unmilled seed; rough seed in the pod. Sainfoin does not develop fully until the second year, and it is therefore considered a good plan to sow from 6 to 8 lb. tre-

[1] Tull's *Husb.* 174, 175 (1762).

foil (*Medicago lupulina*) per acre along with it.

It would be well to defer grazing the sainfoin until after the first cutting has been removed. Young sainfoin is liable to be damaged by being grazed too soon by sheep.

Rye

Rye makes a very useful forage crop. It is wonderfully hardy, and may be sown in autumn or winter for spring use as forage in northern parts, where even vetches cannot be depended upon. It throws up a rank growth, and although it is not so succulent as the vetch, it is, nevertheless, a valuable forage plant, affording, as it does, the earliest green food for sheep or cattle in spring. As already mentioned, it is often sown along with winter vetches.

For spring forage, rye should be sown in autumn immediately after the removal of a grain crop, at the rate of about 3 or 4 bushels per acre. If the land is in good heart, or the crop well manured with dung or superphosphate, and nitrate of soda or sulphate of ammonia, the rye will afford a large produce in the following April, when it may be consumed on the land by sheep, or cut and fed to cattle in the house.

Cabbages.

The cabbage is a most suitable plant for field culture. It is not grown so extensively as might be expected, when one considers the vast amount of wholesome food which it is capable of producing. The variety most largely used is the Drumhead or common cattle cabbage. It is the *Brassica oleracea* of the Natural Order *Cruciferæ*.

The cabbage succeeds best on deep good loams, with porous or well-drained subsoil, and it also does well on well-farmed strong clays. It is a gross feeder, and requires liberal manuring and deep tillage. Land to be planted with cabbage in spring should be deeply cultivated in the autumn or early in winter, and should be well cleaned of root-weeds.

In a paper on "Forage Crops" in the *Farming World Year-Book*, 1889, Mr John Speir says:—

"Probably no ordinary farm green crop admits of growth in a moderately successful way, in a greater variety of soils or climates, than the Drumhead cabbages. With suitable manuring they may be grown on sand, loam, or clay, and on the sea-shore, or well up the mountain-side.

"The seed should be sown in a seed-bed about the middle of July, and the plants transplanted from it to the field in spring. Planting may be done in any suitable weather during March or April, the best crops being usually obtained from the earliest plantings, all other things being equal. By planting moderately early few plants fail to catch root, and as they are rarely hurt by frost after being planted out, they have thus a much longer season in which to mature a full crop.

"Where possible, cabbages should always have their farmyard manure applied to them in the drill. The cabbage is such a gross feeder that it is almost impossible to spoil it by excessive manuring. Any available quantity of farmyard manure, from 20 tons per acre upwards, may therefore be applied, and whatever assistance the crop afterwards requires can be made up by surface manuring with artificials.

"The drills should not be less than 28 or 30 inches in width, and the plants about 2 feet apart in the drill. Planting is best done by the dibble, although some people prefer the spade.

"As soon as the plants have thoroughly taken with the ground, and have begun to spread their leaves across the drill, they should receive from 1 cwt. to 2 cwt. of nitrate of soda or sulphate of ammonia per acre. For a first manuring this is best applied by dropping a little at the root of each plant, 1 cwt. doing as much good at this date, applied in this manner, as 2 cwt. applied broadcast, the plants being so far asunder that a large proportion of such a soluble manure runs to waste. Before the crop is earthed up for the last time, it is always advisable to apply 1 cwt. or 2 cwt. of nitrate of soda or sulphate of ammonia, no matter how much manure may have been applied in the drill. This is best sown broadcast, after the drills are grubbed and before the crop is earthed up. By this means the whole nitrate is turned over on the top of the roots of the plants,

and under their wide-spreading leaves, so that it is protected from washing, no matter whether the season prove wet or dry. Manured in this way, an enormous crop of cabbages can be grown almost any year, on nearly any kind of land.

"Few who have not seen a crop thus manured can form any idea of the weight which may be produced, even under unfavourable circumstances; and certainly for autumn consumption no other crop will produce anything like the same weight of leaves and of an equal feeding value.

Utilising Cabbages.—"Cabbages are well suited for consumption by any kind of farm stock, but for dairy cows they are particularly valuable. They are usually given to the animals raw, although a few people give them boiled or steamed; this, however, is generally considered to be unnecessary. In ordinary seasons the Drumhead cabbage will be ready to use from the beginning of October till the New Year.

"In consuming the crop it is always best to begin by using the largest and ripest cabbages first, as these are the ones to suffer most by frost. In the interval the smaller and greener ones increase considerably in size, and the labour so spent is doubly repaid by the better preservation of the crop, as the small green cabbages suffer little from even severe and protracted frost.

"Where early cabbages are grown for table use, a crop of considerable value is got in autumn from the second growths. Along the sea-shore of the southern counties, thousand-headed cabbages may be grown after early potatoes. Those come in very handy in spring for feeding ewes and lambs, when other green food is extremely scarce."

The storing of cabbages is dealt with at p. 159, vol. i. Cabbages are usually regarded as an exhausting crop. This, however, is only partially true. They are certainly gross feeders, and require heavy manuring; but if they are consumed on the farm the exhaustion does not arise.

About 7000 cabbage plants are required to plant an acre. The produce on good land under liberal and skilful treatment may reach from 50 to 80 tons per acre.

Thousand-headed kale is another Brassica of the cabbage sort, which is much esteemed as food for the sheep-fold. This variety may be sown about the end of April, on rich well-prepared land, at the rate of 4 or 5 lb. of seed per acre, and will produce a bountiful yield of excellent food for sheep in the autumn.

Mr Russell of Horton Kirby, Dartford, Kent, writing of thousand-headed kale, says: "The least known and most desirable of any green crop I have ever seen; it is a plant that produces more food per acre than any other; does not disagree with any stock, nor does it impoverish the land. With me it has never caused sheep or lamb to blow or scour. Eighteen perches a-day with a little oat-straw have kept 270 sheep for three months, without the loss of one." Mr Russell sows the bulk of his crop towards the end of April for use in autumn and early winter, and in August he sows about 20 acres, to be fed off in April and May of the following year. From 4 to 5 lb. of kale-seed is sown per acre.

Transplanting Kale. — Thousand-headed kale gives the best return when the plants are raised in a seed-bed, and planted out like ordinary cabbage. A common plan for feeding purposes is to sow in a seed-bed, early in August, and transplant into well-prepared land, well dunged, in October and November. This should afford an abundant growth for folding in the following summer. If required, a moderate dressing of nitrate of soda would force on the growth of the plants.

Consuming Kale.—Thousand-headed kale thus grown, may either be consumed by sheep being folded upon it, or by the heads being cut off and consumed by sheep on pasture-land. If by the first method the stems are not too closely eaten or peeled by the sheep, the plants will throw out new leaves, and afford a supply of delicious green food in the following spring. In cutting off the heads the bottom leaves should be left, and by taking care not to injure the stocks by either eating or cutting, and not allowing them to run to seed, the plants will endure, and supply useful fodder for several seasons.

Rape.

Rape (*Brassica napus*, Natural Order

Cruciferæ) is grown to a considerable extent as autumn food for sheep in the fold. The main crop is usually sown in June, but small patches may be sown as early as April, to afford successive folds of green food as they may be required. Rape is usually ready for consumption about three months after being sown. About 5 lb. of seed per acre is sown in rows about 15 inches apart. The land should be well dunged, and a dressing of from 2 to 4 cwt. per acre of superphosphate along with the seed will be useful.

Rape delights in fen or peaty soils rich in vegetable mould. It is sometimes sown upon reclaimed peaty land, and consumed by sheep, thus helping to reduce the rough soil to a useful condition. In some cases rape is sown after an early crop of potatoes, and consumed early in winter.

Rape should be hand-hoed like turnips, but is not so carefully thinned, although it undoubtedly affords the largest yield when the plants are thinned out to from 12 to 14 inches apart. Between the rows weeds must be kept down by the horse-hoe or drill-harrow.

Rape is sometimes sown along with vetches, the vetches being sown broadcast over the rows of rape. This mixed crop affords admirable green food for sheep. Rape is also, in some cases, sown in seed-beds, and planted out like cabbages. It is well suited for clay lands when it is sown early and consumed in summer and early autumn, when these lands will bear sheep without injury. Then the early removal of the crop admits of the land being prepared in good time for wheat.

Rape will afford a second crop if the plants are not destroyed, or too closely eaten down when first folded. The second crop however, although often almost as bulky as the first, is not so wholesome for sheep. It is considered injurious to ewes in lamb, and lambs do not thrive well upon it.

Rape is known to possess high fattening properties. It is better to give it along with other foods, such as aftermath, cabbages, vetches, &c., than by itself.

Mustard.

Mustard (*Sinapis albi*, Natural Order *Cruciferæ*) makes a very useful catch crop. It grows up very rapidly, being ready for consumption on the land by sheep in about eight or nine weeks after being sown. The white mustard may be sown in southern counties after an early corn crop, about a peck of seed being sown broadcast. It is sometimes also sown in spring before a late crop.

In many cases it is sown to be ploughed under as a green manure. For this purpose it is also very useful. Besides affording useful manure itself, it helps to prevent the waste of nitrates, which, instead of being washed away in drainage-water —which would probably happen if the soil were bare—are stored up in the growing plant.

Other Forage Plants.

Furze, gorse or *whin* (*Ulex europœus*, Natural Order *Leguminosæ*) as a forage crop has been noticed in vol. i. p. 268.

The kidney-vetch is regarded by some as a useful forage plant. Professor Wrightson thinks it worthy of a trial, and says that it ought to form an ingredient in mixtures of permanent pasture seeds intended for light and thin soils, in which this plant finds its most suitable position.

Maize and *sorghum* are both recommended as forage plants for southern counties. They are undoubtedly unsuited to northern districts, and until they have been more firmly established in this country we think it well to speak of them with caution in this work. As to their feeding properties, and in regard to the attempts to grow them in England, some information will be found in vol. i. pp. 276, 277 and 320-322.

The character of *prickly comfrey* (*Symphytum asperrimum*, Natural Order *Borragineæ*) as a forage crop is also referred to in vol. i. p. 277. For odd corners it is undoubtedly a most useful crop. It requires heavy manuring. It is perennial, and the plants are dibbled in 18 inches apart, in rows from 18 inches to 2 feet apart.

Buckwheat is also of some use as a forage crop. It is very susceptible of injury from frost, and can seldom be sown with safety earlier than May.

PLANTING POTATOES.

As a rule the potato crop, cultivated on the fallow division of the farm, follows a crop of oats, which, in turn, had succeeded pasture. In some districts potatoes come after lea, and this many consider the best place in the rotation for the crop.

Land for Potatoes.—Potatoes thrive best on light dry, friable, or sandy loams. They also do well upon virgin soils and mossy or turfy land, but seldom give good results on strong, tenacious clays, with retentive subsoil.

Tillage for Potatoes.—The stubble land intended for potatoes is ploughed early in the autumn, so that it may have the full benefit of the ameliorating influences of winter. Potato land should be tilled early in spring, and cleaned as well as possible. The time for *cleaning* land is usually limited in spring, so that the cleanest portion of the fallow-break should be chosen for the potatoes to occupy.

The stubble land will either have been cast in autumn, or cloven down without a gore-furrow, according as the soil is strong or light. Having been abundantly provided with gaw-cuts, to keep it dry all winter, it may be in a state to be cross-ploughed or cultivated soon after the spring wheat and beans have been sown, where either is cultivated; and where not, preparing the potato land is the earliest work in spring after the ploughing of lea. After the cross-ploughing or grubbing, the land is thoroughly harrowed with a double tine along the line of the furrow, and a double tine across it, and any weeds brought to the surface and gathered off. If the land be clean, it is then ready for drilling; if not, it should receive a strip of the grubber in the opposite direction, and again be harrowed, and any weeds gathered off.

The cross-ploughing of potato land in spring is not so extensively practised now as formerly. With deep autumn or winter ploughing less spring stirring suffices, and if the land is clean, and the soil fine and friable, rank harrows may do all that is necessary. Most likely, however, a strip of the grubber will be beneficial; and as grubbing is a speedy operation it need not long delay the planting.

The grubber indeed is a better implement for stirring the soil, under the circumstances, than the plough, as it will retain the dry surface still uppermost, and bring to the surface the weeds that have entangled themselves about the tines. The time occupied in doing all this, according to the character of the weather, may be about a month, from early in March to early in April, when the potatoes should be planted.

In cultivating land for potatoes, it is important to remember that the roots and tubers should have free scope to ramify in soil.

Manuring Potatoes.

Farmyard dung is the staple manure for potatoes. Without a certain amount of dung they are seldom grown; and heavier dressings of dung are employed for potatoes than for any of the other ordinary crops of the farm. From 15 to 20 tons per acre are common quantities, and often as much as 25 to 30 tons per acre is applied.

Mechanical influence of Dung on Potatoes.—It is obvious that the potato crop cannot make immediate use of more than a small portion of the plant-food contained in these heavy dressings of dung. Farmyard manure, however, would seem to be far more to the potatoes than a source of nutrition. Its mechanical influence upon the soil has evidently a peculiarly beneficial effect on this crop. It not only opens up the soil and renders it more friable, but by the decay of the organic matter the temperature of the soil is raised, thus surrounding the potato with more kindly conditions than would have existed in the absence of dung. These heating and pulverising influences of dung are undoubtedly of great importance; and we are inclined to think that a good deal more of the value of dung as a manure lies in these functions or influences than has usually been associated with them.

Typical Dressings.—In the Lothians of Scotland, where potato-growing is a prominent feature in the system of farming, the dressing of dung ranges from 20 to 30 tons per acre—even as much as 35 or 40 tons per acre being occasionally used for an early crop. In addition to these allowances of dung, from 5 to 10 cwt. of artificial manure is applied, the latter consisting of guano, dissolved bones, superphosphate, and perhaps a little potash, or instead of guano, nitrate of soda or salts of ammonia. A dressing of 6 cwt. of artificial manure sometimes used with about 20 tons of dung, consists of 2 cwt. bone-meal, 1 cwt. vitriolised bones, 1½ cwt. of mineral superphosphate, 1 cwt. sulphate of potash, and ½ cwt. sulphate of ammonia. On light lands in Ayrshire, where potatoes are successfully grown for early consumption, very heavy manuring is practised. In some cases here as much as 30 tons of dung, and 12 to 15 cwt. of artificial manure, is applied per acre—the artificials consisting of 4 or 5 cwt. of kainit, and 8 or 10 cwt. of a mixture containing from 8 to 10 per cent of ammonia and 20 to 30 per cent of phosphate.

Quickly acting Manures for Potatoes.—For potatoes, manure should be supplied in a readily available form near at hand, as it is a moderately or rapid growing, feebly rooted plant. It is thus desirable that, however much dung may be applied, a certain quantity of more quickly acting manure should also be given. It may be that the dressing of dung will contain far more nitrogen, phosphoric acid and potash, than the crop of potatoes will require. Experience, however, has clearly shown, notably in the case of the Rothamsted experiments (p. 264), that only a very small portion of the plant food in the dung can be utilised by the first crop of potatoes. Thus, while the heavy dressing of dung is beneficial, partly as a source of manure and partly on account of its mechanical influence on the soil, it is necessary to apply phosphates, nitrogen, and potash, in forms in which they will be immediately available to the crop. For this purpose, bone-meal or mineral superphosphate, or both, guano, sulphate of ammonia or nitrate of soda, and kainit, are most largely used.

Dr Aitken on Manuring Potatoes.

With special reference to the experiments conducted under the auspicies of the Highland and Agricultural Society, Dr A. P. Aitken writes as follows as to the manuring of potatoes:—

"The potato is a feeble rooter, and requires its manurial food to be closely within reach. In order that the tubers may be able to expand, the soil about them must be loose. Manures which keep the roots free are therefore very appropriate. There is nothing so suitable as dung for that purpose, but any very bulky manure is also good, and especially if it has a large proportion of organic matter to keep the soil warm and make a soft compressible seed-bed.

Form of Manures for Potatoes.—"The potato is not well adapted for utilising insoluble materials, and therefore any artificial manures applied with the dung should be of a soluble, or, at least, not very insoluble kind. Superphosphate is better than ground mineral phosphates or bone-meal; and even dissolved bones is rather a slow manure for this crop.

Nitrogen for Potatoes.—"The most important ingredient of a potato manure is nitrogen, and the most of it should, as has been said, be of a soluble quick-acting kind. Insoluble nitrogenous matters do not come into activity quickly enough for the wants of the crop. When dung is used, there is no better way of increasing the nitrogenous manure than by giving some *nitrate of soda* along with the dung.

"*Sulphate of ammonia* along with dung is to be avoided. It not only produces a smaller crop than the nitrate of soda, but it causes the production of an undue proportion of small tubers.

"On the other hand, if no dung is being applied to the potatoes, sulphate of ammonia is an excellent nitrogenous manure, especially in a wet season.

Potash for Potatoes.—"As regards *potash* the wants of the potato crop are peculiar. The potato plant takes away a great deal of potash; and fields on which potatoes are frequently grown very soon become exhausted of potash. This must be made good, for the potato is very dependent on potash manures. Where

much dung is used there is little need of applying extra potash manure, seeing that dung is so rich in potash; but where dung is used for the green crop, only an addition of potash salts is to be recommended, for much of the potash in dung is not very readily available.

Too much Potash Injurious.—"Where no dung is used, potash forms an exceedingly important ingredient. The limit of potash manure required for potatoes is nevertheless very soon reached; and no good but rather harm is done by overdoing the application of potash.

"It is a common practice to apply very large doses of light manures to the potato crop. Much extravagance may occur in that way, and sometimes more harm than good result. It is important in such cases that the manure should not be placed in direct contact with the sets. It should rather be applied some time before planting, and should be well incorporated with the upper layer of the soil as a general fertilising application.

Proportion of Manurial Elements.—"When no dung is used, the proportion of the manurial ingredients in a well-balanced potato manure, will be just about equal parts potash, ammonia, and phosphoric acid. When applied along with dung the potash may be diminished by half, and the nitrogen slightly increased."

Rothamsted Experiments with Potatoes.

An interesting series of experiments upon the manuring of potatoes has been conducted at Rothamsted. The results have been fully explained by Dr Gilbert in his lectures at Oxford and Cirencester, and several of them are of considerable practical value to farmers.

Farmyard manure was tried by itself and in conjunction with nitrogenous, phosphatic, and potassic manures. The potatoes were grown on the same land every year, and on this account the results cannot be unreservedly applied to potato culture under ordinary rotation farming. Still some lessons of importance may be learned.

Farmyard Dung.—This was applied at the rate of 14 tons per acre every year, and the average yield for six years was 5¼ tons per acre—just over 3 tons more than the plot which had no manure of any kind in those six years.

Dung and Superphosphate.—The addition of 3½ cwt. superphosphate of lime to the dung had very little influence on the crop. The yield rose to 5 tons 12 cwt., or an increase of 7 cwt. over the dung alone.

Dung, Superphosphate, and Nitrate of Soda.—But when the dung and superphosphate were supplemented by some nitrate of soda, supplying 86 lb. of nitrogen per acre, a marked difference upon the crop became apparent. The produce rose to 7 tons 2 cwt.—an increase of 1½ ton, due to the 86 lb. of rapidly acting nitrogen.

Artificial Manures.—Artificial manures were also tried by themselves, separately, and in different combinations.

Superphosphate of lime (3½ cwt. per acre) applied alone gave an average of 3 tons 13⅜ cwt. for twelve years—nearly 2 tons 6 cwt. more than the no-manure plot.

Mixed mineral manure (consisting of 3½ cwt. per acre of superphosphate, 300 lb. sulphate of potash, 100 lb. sulphate of soda, and 100 lb. sulphate of magnesia) gave only 2 cwt. per acre more than the superphosphate alone.

Salts of ammonia (450 lb.) alone gave a poor result—only 2 tons 5¾ cwt. per acre, or 6 cwt. more than the unmanured plot.

Nitrate of soda (550 lb.) alone did little better. It exceeded the salts of ammonia by 7 cwt. per acre.

Nitrogenous and mineral manures mixed produced very different results. Applied together to the same plot they raised the produce to an average of over 6½ tons—6 tons 14½ cwt. for salts of ammonia and mixed mineral manure, and 6 tons 13 cwt. for nitrate of soda and mixed mineral manure.

Conclusions.—In contrasting these experiments with various kinds and dressings of manure, some noteworthy results are observed. As to *artificial manures* it is shown (1) that the exhaustion of phosphoric acid by the potatoes was greater than that of potash; (2) that in the continuous growth of potatoes here it was the available supply of mineral constituents within the root-range of the plant, more than that of nitrogen, which became deficient—hence the greater pro-

duce from mineral manures alone than from nitrogenous manures alone; (3) that it is only when all the essential elements of manure are present in sufficient quantity that the full benefit of any kind of dressing can be derived; and (4), that when thus applied together in a well-balanced dressing, artificial (nitrogenous and mineral) manures produced a crop which for twelve successive years exceeded the average yield of the United Kingdom—decidedly greater indeed than the yield from farmyard manure alone, and only about 8 cwt. per acre behind the produce from a combined dressing of dung, superphosphate, and nitrate of soda.

The efficacy of well-proportioned artificial manures for potatoes thus demonstrated at Rothamsted is a consideration of great importance to farmers. Equally valuable to the practical farmer is the unquestionable conclusion that, in efficient and profitable manuring, an essential condition is that the dressing shall be properly balanced—that is, contain all the necessary elements of plant-food in due proportion.

Slow Exhaustion of Dung.—In the Rothamsted experiments with potatoes some interesting information has been brought out as to the behaviour of farmyard manure in the soil. The most striking point in these results is the slow action of the dung, particularly of the nitrogen it contained. The dressing of dung applied annually to the potato crop contained, per acre, about 200 lb. of nitrogen—besides, of course, an abundance of mineral matters, &c.; yet from 86 lb. of nitrogen, supplied in the form of nitrate of soda or salts of ammonia, along with an artificial mixture of mineral manures, the average produce was considerably greater than from the dung, Thus it is observed that, while the dung supplied far more nitrogen than the crop required, it did not contain enough in such a readily available condition as that it could be at once seized by the crop.

Further striking evidence of the slow action of nitrogen in dung was furnished by the fact that by supplementing the dung with some quickly acting nitrogen—86 lb. of nitrogen per acre in nitrate of soda—the produce of the tubers was increased by over 1½ ton per acre.

Residue of Dung.—Then as to the residue of dung, the results showed that it acted very slowly. Of the nitrogen supplied in the annual dressing of dung only about 6.4 per cent had been recovered in the crop of potatoes in the first six years. In the succeeding six years potatoes were grown every year on the same plot without any further application of dung or other manure, and in that time only 5.2 per cent of the unrecovered nitrogen was taken up in the crop. Thus in twelve years only 11.6 per cent of the nitrogen supplied in the dung during the first six years had been recovered in the crop.

Dr Gilbert on Dung for Potatoes.—Referring to this point in his Cirencester lectures, Dr Gilbert says: "In the case of other crops it has been found that only a small proportion of the nitrogen of farmyard manure was taken up in the year of application. But these results seem to indicate that the potato is able to avail itself of a less proportion of the nitrogen of the manure than any other farm crop. Yet in ordinary practice farmyard manure is not only largely relied on for potatoes, but is often applied in larger quantity for them than for any other crop. It is probable that, independently of its liberal supply of all necessary constituents, its beneficial effects are in a considerable degree due to its influence on the mechanical condition of the soil, rendering it more porous and easily permeable to the surface-roots, upon the development of which the success of the crop so much depends. Then, again, something may be due to an increased temperature of the surface soil, engendered by the decomposition of so large an amount of organic matter within it; whilst the carbonic acid evolved in the decomposition will, with the aid of moisture, serve to render the mineral resources of the soil more soluble."

In considering these results obtained at Rothamsted it should, of course, be borne in mind that the system of cropping pursued on the experimental plots there—the same crop on the same plot every year—differs greatly from that followed in ordinary farming. In all probability, with the more thorough and varied tillage, and the cropping with plants of different depth of roots and dif-

ferent powers of assimilating food which obtain in ordinary rotation farming, the residue of dung would be more speedily recovered by crops than was the case at Rothamsted. Still it can hardly be gainsaid, that the Rothamsted experiments have proved that the beneficial influence of dung upon potatoes is due in a larger measure to its mechanical effect, and in a less degree to it as a source of plant-food, than was before generally believed.

A Practical Lesson.—The chief lesson which the practical farmer is to draw from these conclusions, as to the action of dung, is that, while a large dressing of dung may with advantage be applied for potatoes, it must not be relied upon as the sole source of plant-food for the crop—that the dung must be supplemented with a substantial allowance of quick-acting nitrogenous manure, such as nitrate of soda, and with a smaller application of phosphates and potash.

Potash for Potatoes.—The undoubted value of potash for potatoes is not very clearly shown in the Rothamsted experiments. In soils deficient in available potash the application of about 2 or 3 cwt. of kainit per acre will be found to have quite a wonderful effect on the produce. Good results have been obtained from kainit when sown as a top-dressing just before the drills of potatoes are earthed up for the first time, especially when rain happened to fall soon after, thus carrying down the potash to the roots of the crop, which is then ready to absorb it. Mr John Speir says he prefers to sow the kainit on the ploughed land in autumn or early winter, which indeed is generally believed to be the best plan.

Application of Manure for Potatoes.—Occasionally, chiefly in stiff soil, the dung for potatoes is spread upon the land and ploughed in late in the autumn or in winter. In that case the land is again ploughed in spring or perhaps first grubbed, and then ploughed and the seed planted on the flat in every third furrow, the artificial manure being sown just before the last ploughing, or deferred till the plants are hoed or earthed up the first time. But the most general system is to spread the dung in the drills, sow the artificial manure on the top of this, and then plant the seed, and cover all in together by splitting each drill with the drill plough.

Details of Planting.

The planting of potatoes demands attention early in spring.

Potato-seed.—While the land is being prepared for the potatoes—and it will not be possible to prepare it continuously, as the sowing of grain has to be attended to—the *potato-seed* should be prepared by the field-workers. When preparing potato-seed a great saving of time will be effected if the seconds (*i.e.*, after the ware has been taken out) are dressed over 1¼ inch riddle, and then over 1¾ inch riddle. The tubers above the 1¾ inch should be taken to an outhouse and cut, while the smaller ones can be covered up again and planted whole. In selecting tubers to cut into sets, the middle-sized, that have not sprouted at all, or have merely sprouted buds, will be found the soundest; and wherever the least softness is felt, or rottenness seen, or any suspicion as regards colour or other peculiarity is indicated, the tuber should be entirely rejected, and not even its firm portion be used for seed. The very small potatoes should be picked out and put aside to boil for poultry and pigs.

Potatoes intended for seed should always be turned in the pits between February and March, in order to prevent sprouting. This checks the growth, and plumps up the buds wonderfully.

Potatoes are planted whole or cut into parts or *sets*. Large whole potatoes should not, as a rule, be planted, as it is a waste of seed. Some kinds of potatoes, however, such as Magnum Bonum, are best planted whole. With the Magnum Bonum, growth begins so late in the season, that at cutting time it is impossible to say whether or not any eye will grow. They have few "eyes," which are nearly all at one end, and when cut the part containing the eye is thin. Very small sets, or very small whole potatoes should not be used as seed, as they are liable to produce a light crop of puny tubers. Moderately small tubers, if they have not too many eyes, make good seed.

The usual practice is to cut a middle-sized potato into two or three sets, according to the number of eyes it contains. It is well to leave two eyes in each set,

lest one of them may have lost its vitality. The sets should be cut with a sharp knife, be rather large in size, and taken principally from the rose or crown end of the tubers. The other heel or root end may be kept for pigs or poultry. When fresh the tubers cut crisp, and exude a good deal of moisture, which soon evaporates, and leaves the incised parts dry.

A common practice was to heap the cut sets in a corner of the barn until they were planted. Had they been exposed previously to drought they might remain uninjured, but if heaped immediately on being cut, in a moist state, they will probably *heat*, and heated potatoes, whether whole or cut, rarely vegetate. Much of the injudicious treatment which sets of potatoes receive arises from want of room to spread them out thin. The straw-barn is most generally used, but in many cases it cannot be spared, as the cattle-man and ploughman must have daily access to it. The corn-barn may be occupied with grain. The implement-house has too little room—besides the many small articles which it contains. The only alternative is an outhouse; a large one should be in every steading.

A considerable quantity of seed should be prepared before planting is begun, and the rest can be made ready when the horses are engaged with the barley or oat seed, or during any broken weather. A considerable quantity of seed can usually be stored about the steading for cutting in wet or stormy weather; while the rest can generally be prepared at the pit-side.

Preserving Sets.—When cut indoors the sets should be spread out thin and dusted with lime. This forms a crust on the incised surface,[1] and prevents the sap from exuding. Potatoes are best cut a day or two before planting, as they keep longer fresh in the ground when there is a crust on the incised surface of the set.

Quantity of Seed per Acre.—The sets required to plant an acre of land vary very much according to size of sets and kinds of potatoes. From 8 to 10 cwt. of cut Regents will plant an acre, while from 10 cwt. to 14 cwt. of whole Magnums will be required.

Since the prevalence of disease among potatoes in all soils and situations, numerous expedients have been devised to prepare the seed, with the view of warding off disease, but without much practical effect.

Potatoes not required for seed, firm and of good size, whether intended for sale or for use in the farmhouse, should remain in the outhouse until disposed of or used, kept in the dark, with access to air, and examined as to soundness when the sprouts, if any, are taken off.

Planting on the Flat.—In many parts of England, where the climate is dry, potatoes are grown extensively on the flat. There autumn or winter dunging is often practised, and by grubbing, harrowing, and ploughing, the land is prepared for the seed in spring. As already stated, the seed in this case is dropped into every third furrow, the seeds being from 9 to 14 inches apart in the furrow. The spaces between the rows of potatoes are hoed by horse and hand hoes just as in the case of drills, and when the plants are well grown they are earthed up by passing a double mould plough between the rows, thus forming ordinary drills.

The Drill System.—But the growing of potatoes in drills is far better than planting on the flat. The drill system is all-prevailing in Scotland (except in some parts of the Highlands and Western Islands) and the northern counties of England, while it greatly predominates in Ireland, except on small holdings where the "lazy-bed" method is still pursued extensively.

Autumn Dunging.—If the land is strong and a supply of dung happen to be then on hand (which, however, is not often the case), it is considered a good plan to spread the dung for potatoes on the stubble just before ploughing in the end of autumn or early in winter. This, no doubt, tends to the better preparation of strong land for potatoes; and the carting and spreading of the dung in autumn or winter lightens the pressure of work in spring. One great hindrance to this system is the fact that a sufficient supply of dung is not usually available in the autumn or beginning of winter. Where summer-house feeding is practised, there is generally an ample supply of dung in good time for this purpose; and these two systems, which, in suitable circumstances, are both to be commended, fit well into

[1] *Trans. High. Agric. Soc.*, xiv. 144.

each other. On dry soils and in dry seasons dunging before ploughing usually gives the best results. In the opposite conditions spring dunging will be found to excel.

Spring Tillage with Autumn Dunging.—When the potato land has been dunged and deeply ploughed in autumn or winter, the spring tillage is simple and soon finished. If the land is clean no further ploughing may be necessary. A single or double stripe with the grubber and moderate harrowing will most likely suffice, and then shallow drills are opened from 28 to 30 inches wide. The seed is planted in these drills with from 10 to 14 inches between the sets, and an allowance of artificial manure is sown, and the drills are closed by splitting each ridgelet in two with the drill-plough, of which an

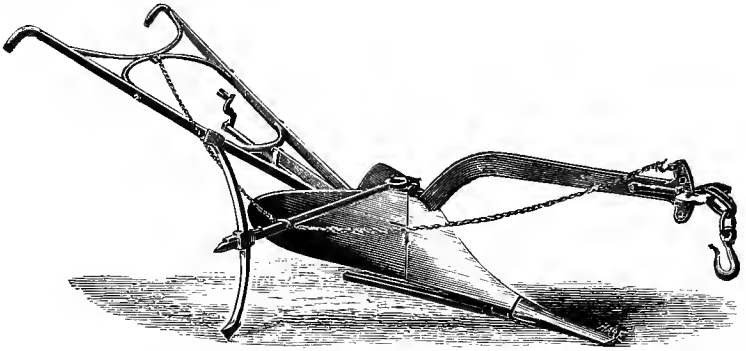


Fig. 320.—*Scotch drill-plough.*

improved Scotch pattern, made by A. Newlands & Son, Linlithgow, is represented in fig. 320.

Spring Dunging.—The more general practice is to apply both the dung and the artificial manure in the drills at the time of planting in spring. If the land is clean and not too rough, a small amount of spring tillage will suffice. When they have to hold dung, as well as the seed and artificial manure, the drills have to be a little deeper than is necessary with previous dunging on the surface.

Carting Dung for Potatoes.—The more expeditious plan is to have the dung carted in a heap on the field before the rush of spring work sets in. In this case the carting of the dung into the drills is speedy work. But it is very often found that better crops of potatoes are obtained from dung carted right from the cattle-court to the drills than from exactly similar dung which had some time before been carted into a heap on the field. Where the lessening of spring work is of special importance, as in late districts, with their long winter and short growing season, it will perhaps still be best to pursue the practice of carting the dung to heaps on the field in winter. In cases, however, where there is no such excessive rush of spring work, and where the potato field is within easy distance of the homestead, the dung had better be left in the courts till required for the drills in spring, or until it is to be spread upon the land in one form or other.

Details of Planting.—In the afternoon before the day on which the planting of potatoes is to be commenced, the drill-plough should be set to work to open a few drills, so that on the following morning the full force of men, women, boys, and horses, may at once get into action. As soon as the carts with the dung get into drills they are followed by men, women, and boys spreading the dung. These again are closely succeeded by women and boys planting the seed, and by a man sowing the artificial manure. One or two drill-ploughs are opening drills, and one or two closing in, according to the size of the farm and the extent to which potatoes are cultivated. In some cases the ploughs open one way and cover the other.

Single *v.* Drill Plough.—Mr Speir, Newton Farm, Glasgow, says: "On any

land, fine or firm, where one or more ploughs can be kept in constant work, a single mould-board plough with a specially narrow mould-board on, makes *much better* work and is easier held than the double one. With it the soil is lifted and turned right over on the dung and sets—not *shoved* over as with the other. Here no double mould-boards are used at planting time." It is very important that the double mould plough should be formed so as to turn over rather than press the soil outwards.

Upon a large farm, where a considerable area is devoted to potatoes, the operations of opening drills, carting dung, spreading dung, planting seed, sowing artificial manure, and closing in drills, are all proceeding simultaneously. There is no more active scene upon a farm in the course of the whole year than this; and few operations afford greater opportunities for the exercise of skill and forethought in arranging and controlling farm labour.

Filling Dung.—To avoid delay in the field, and keep the horses as active as possible, one or two men may be employed at the dung-heap in assisting the drivers of the carts in throwing the dung into the carts, which is done with ordinary four-pronged steel graips. The movements of the carts are so arranged that only one, or at most two carts are at the dung-heap getting filled at one time.

Distributing Dung from Carts.—The dung is thrown from the cart into the drill in graipfuls as the horses move on at a moderate pace. The quantity of dung intended to be given to the land is evenly apportioned by the farmer or overseer, fixing the length of drill which loads of certain size should cover, and seeing that the man throws out the dung in uniform graipfuls at regular distances. Intelligent horsemen very quickly become expert at this practice, which is far more expeditious and satisfactory than the antiquated method of dragging the dung out of the cart into heaps in the drills.

Three ordinary drills are just about the width of a farm-cart. The dung is often thrown into the drill in which the horse is walking, and one wheel of the second cart thus runs over the dung thrown out from the first cart. This packing of the dung by the cart-wheel should be avoided by throwing the dung, not into the centre drill, but into the drill on the side of the cart next to where the dunging was begun.

Spreading Dung.—The spreading of the graipfuls of dung in the drills is done by men, lads, and women.

In England women are rarely seen at this work, and in Scotland also the custom of employing them at it is by some strongly condemned as unbefitting modern civilisation. We shall not enter upon a discussion of the question here. Our object is rather to describe practices as they exist. Certainly much less female labour is now engaged in outdoor farmwork than in former times, and the tendency is still towards diminution.

In many parts of Scotland women are still extensively employed in spreading dung. It is undeniable that they do it almost as well and as expeditiously as average men; and they are usually far superior to lads and boys. A long-shafted steel fork or graip, with three or four prongs, is best suited for spreading dung. It is very important that the dung should be finely broken and evenly spread in the drill. Lumps of dung should be thoroughly broken, and rolls of straw or other litter undone, so that the dung may not only be evenly distributed over the land, but be so exposed to the surrounding soil as that it may speedily and regularly decompose.

Four or five workers will, in average circumstances, spread as fast as one drill-plough can cover in.

Planting the Seed.—The spreaders of dung are followed immediately by a similar force planting the seed. Women make the best planters. Five or six planters with the seed regularly supplied to them will plant as fast as the four or five workers will spread the dung; and this force of spreaders and planters, with one man to sow the artificial manure, will keep one drill-plough at full work in covering in. It is perhaps better that each planter carry her own sets, as a relief to the stooping posture is thus obtained, and each planter should have a separate drill, otherwise parts may be missed. The sets are dropped into the drill upon the top of the dung, at from 9 to 14 inches apart.

Planting-machines.—Machines have

been invented for planting potatoes, but have not come into use to any considerable extent. They plant only whole sets.

Conveying Seed to the Planters.—The sets are shovelled either into sacks like corn, or into the body of close carts, and placed, in most cases, on one or both head-ridges or middle of the field, according to the length of the ridges. When the drills are short, the most convenient way to get at the sets is from a cart; but when drills are long, sacks are best placed along the centre of the field. A still better plan, if a horse can be spared, is for a boy to drive the potatoes alongside the planters. The cart can go in the drills that are covered, and the boy will carry the sets to the workers.

In some cases a small round willow basket, with a bow-handle, fig. 321, is provided for each person who plants the

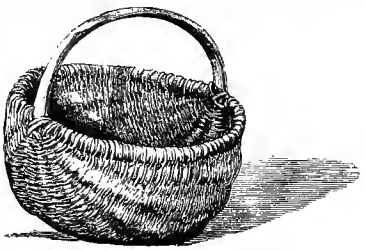


Fig. 321.—*Potato hand-basket.*

sets. Others prefer aprons of stout sacking. As a considerable number of hands are required, boys and girls may be employed beyond the ordinary field-workers. The frying-pan shovel, fig. 252 (vol. ii.), with its sharp point, is a convenient instrument for taking the sets out of the cart into the baskets.

Sowing the Artificial Manure.—Whatever artificial is to be given at the time of planting is sown broadcast by hand along the drills, after the dung is spread, and either before or after the seed is planted. A man sowing with two hands will sow as fast as three drill-ploughs can cover in.

Covering in.—The drill-plough should at once follow the planters, as both dung and potatoes suffer by being exposed to the sun. The drills are split in the same way as they are set up—that is, the plough splits the drill, throwing one-half of the land on one row of sets and the other half on the other, both of the drills being completely covered in two rounds of the plough. The whole of the drills dunged and planted should be covered every day—the man who has been opening helping the one who is covering, after he has opened enough to serve for the day, with a few for a start next morning.

Where there is only one drill-plough, it is employed alternatively in opening and covering in, or opens one way and covers the other. Or the single board plough is used as described on page 267.

Complete Planting as it proceeds.—It is undesirable to open many more drills than can be planted and covered in before nightfall, lest inclement weather should set in, and so render the opened drills too stale before the planting can be resumed. The work of planting is done most satisfactorily where, as far as it goes, it is begun and completed in the same day.

Danger of leaving Dung and Seed uncovered.—Most farmers are specially careful as to the completion of the work of potato-planting as it goes on. In many cases it is insisted that, even at loosing from the forenoon yoking, every drill should be covered in, although the ploughman should work a little longer than the rest of the work-people; for which detention he would delay as long in yoking in the afternoon. In dry hot weather he should make it a point to cover in the drills at the end of the forenoon yoking in a complete manner, as dung soon becomes scorched by the mid-day sun, and in that state is not in good condition; not on account of evaporation of valuable materials, as what would thus be lost would be chiefly water, but because dry dung does not incorporate with the soil for a long time, and still longer when the soil is also rendered dry. If all the ploughs cannot cover in the drills at the hour of stopping at night, give up dunging the land and planting the sets a little sooner, rather than run the risk of leaving any dung and sets uncovered.

Width of Potato-drills.—Drills for potatoes should be made 28 inches to 30 wide, according to kind of potato. Abundance of air is of great importance to the potato plant. Near large towns

the drills are made narrower, from 24 inches to 27 inches, the early varieties of potatoes chiefly cultivated there having comparatively small stems.

Width and Depth of Sets.—The distance between the sets in the drill varies from 9 to 14 inches, according to the width of the drill, the variety of potato, whether the stems are tall, medium, or short, and the character and condition of the soil and climate, whether likely to favour a heavy or light yield, and the size of the sets. Sets placed 6 inches under the surface yield the greatest crop; at 3 inches the plants are weak; and at 9 inches many never come up at all.

Experiments with Late Planting.—The main bulk of the potato crop is usually planted in spring, except in the later districts, where it is generally done early in May.

It has been suggested that in certain circumstances potato-planting might be more remunerative if the tubers were not planted until June. Mr John Speir, Newton Farm, Glasgow, conducted experiments with plantings on different dates in June and July in the years 1888 and 1889. Early varieties were planted—whole seed which had been strongly sprouted before being set. Farmyard dung alone was used. In 1888, the planting on June 30 gave about one-third more produce than the planting ten days later. The July plantings were still more unsuccessful in 1889, but in both years the June plantings gave satisfactory results. In June 1889 three plantings gave the following results:—

Planted.	Produce.
June 10 . . .	7 tons per acre.
" 20 . . .	5½ "
" 29 . . .	4 "

Mr Speir is quite convinced that the system is capable of great expansion, more particularly on market-garden farms or in late districts. But he adds, that to be attended with any measure of success at all, *the seed must be sprouted, and the sprouts must never have been broken off, but be the first ones which come.*

An Ayrshire Practice.—On the earliest farms along the coast of Ayrshire, principally around Girvan, Maybole, and Ayr, where the area of potatoes grown is excessively large in proportion to the size of the farms, a different class of plough is used from that which is commonly met with throughout the country. There the area planted is so great in proportion to the power at the command of the farmer, that a speedier method must be adopted than that in general use. The plough (one of which, made by T. Hunter, Maybole, is shown in fig. 322) has very much the appearance of an ordinary 3-horse grubber, at least so far as the frame is concerned, while it has also two similar side-wheels, a fore-wheel, and lifting lever. Instead, however, of from five to seven tines, it has only three, all set abreast, each tine being in fact a double mould-board plough hung from the frame. The mould-boards are a little less in size than those in use in the ordinary mould-board plough, but otherwise they are the same. By this plough, with three horses, three drills are opened or covered at one passage of the plough. To work it properly the land must of necessity be well prepared beforehand, and any farmyard manure which is to be used has generally been ploughed in some time previously.

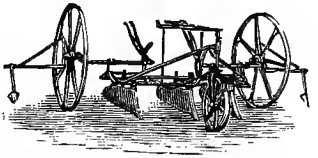


Fig. 322.—*Triple drill-plough.*

In this district, where much of the best potato-land is very sandy, a peculiar class of double mould-board plough is also used to earth up the potatoes. In it the mould-boards are solid and continuous from the sole of the plough to the top of the drill, so that in working in dry weather the whole weight of the plough is exerted in pressing the sandy earth on the side of the drill, and in the driest weather slipping down rarely happens. The same class of plough is in use on the early potato-lands of Cheshire, from which district the Ayrshire men adopted it.

The Lazy-bed System.—Another mode of field-culture for potatoes is in *lazy-beds*, very common in Ireland. This system is becoming less general on arable land, though on lea-ground it gives very good results, and seems indeed to be

best suited to certain circumstances. In the island of Lewis drill-sowing was at one time adopted, but found unsuitable for the soil and climate, and the lazy-bed system had again to be resorted to. The usual method is to remove a line of turf along the margin of the proposed lazy-bed, after which a slight covering of dung is given, and the next line of turf turned over green side under upon the top of the sets. The next line is turned over without sets, then dung, &c.; this proceeding being adopted along the whole bed, until finished, after which a trench is cut or formed round the edges to carry off any surplus moisture.

In reference to Ireland, Martin Doyle says: "In bogs and mountains, where the plough cannot penetrate through strong soil, beds are the most convenient for the petty farmer, who digs the sod with his long narrow spade, and either lays the sets on the inverted sod—the manure being previously spread—covering them from the furrows by the shovel; or, as in parts of Connaught and Munster, he stabs the ground with his *loy*—a long narrow spade peculiar to the labourers of Connaught—jerks a cut set into the fissure when he draws out the tool, and afterwards closes the set with the back of the same instrument, covering the surface, as in the case of lazy-beds, from the furrows.

"The general Irish mode of culture on old rich arable lea is to plough the fields in ridges, to level them perfectly with the spade, then to lay the potato-sets upon the surface, and to cover them with or without manure by the inverted sods from the furrows. The potatoes are afterwards earthed once or twice with whatever mould can be obtained from the furrows by means of spade and shovel. And after these earthings, the furrows, becoming deep trenches, form easy means for water to flow away, and leave the planted ground on each side of them comparatively dry.

"The practice in the south of Ireland is to grow potatoes on grass land from one to three years old, and turnips afterwards, manuring each time moderately, as the best preparation for corn, and as a prevention of the disease called fingers-and-toes in turnips. In wet bog-land, ridges and furrows are the safest, as the furrow acts as a complete drain for surface-water; but wherever drilling is practicable, it is decidedly preferable, the produce being greater in drills than in what may be termed, comparatively, a broad-cast method." [1]

Culture after Planting. — Potatoes require a considerable amount of horse-work both before and after brairding. As soon as convenient after planting, the drills should be harrowed down either with a set of light zigzag harrows or chain-harrows, or, better still, with a saddle-drill harrow, such as is illustrated in fig. 273, p. 205. Immediately after, the drills are again set up with the double-moulded plough. When the plants are well sprung, but before they are too far advanced, the drills should be again harrowed down. This makes a fine surface for the young plants, and helps to keep down weeds. A very suitable implement to crush clods on strong land is a fluted roller to embrace two drills. This crushes the clods, and rolls them into the hollow of the drills.

Hand-hoeing. — The drills are then hand-hoed, loosening the soil around the young plants and removing weeds. The hollows of the drills are stirred with the drill-harrow or horse-hoe, and then the drills are set up with the double mould plough. Unless weeds are so abundant and strong as to necessitate another hoeing, no further tillage may be required.

Varieties of Potatoes.

The potato belongs to the class and order *Pentandria Monogynia* of Linnæus; the family *Solaneæ* of Jussieu; and to class iii. *Perigynous exogens;* alliance 46, *Solanales;* order 238, *Solanaceæ;* tribe 2, *Curvembyreæ;* genus *Solanum* of the natural system of Lindley. — On this remarkable family of plants, Lindley observes that they are "natives of most parts of the world without the arctic and antarctic circles, especially within the tropics, in which the mass of the order exists in the form of the genera *Solanum* and *Physalis*. The number of species of the former genus is very great in tropical America. At first sight this order seems to offer an excep-

[1] Doyle's *Cy. Prac. Husb.*—art. "Potato."

tion to that general correspondence in structure and sensible qualities which is so characteristic of well-defined natural orders, containing as it does the deadly nightshade and henbane, and the wholesome potato and tomato; but a little inquiry will explain this apparent anomaly. The leaves and berries of the potato are narcotic; it is only its tubers that are wholesome when cooked. This is the case with other succulent underground stems in equally dangerous families, as the cassava among spurgeworts; besides which, as De Candolle justly observes, 'Il ne faut pas perdre de vue que tous nos alimens renferment un petite dose d'un principe excitant, qui, s'il y etait en grande plus quantité pourrait être nuisible, mais qui y est nécessaire pour leur servir de condiment naturel.' The leaves of all are, in fact, narcotic and exciting, but in different degrees, from *Atropa belladonna*, which causes vertigo, convulsions, and vomiting, to tobacco, which will frequently produce the first and last of these symptoms; henbane and stramonium, down to some Solanums, the leaves of which are used as kitchen herbs. . . . An extract of the leaves of the common potato, *Solanum tuberosum*, is a powerful narcotic, ranking between belladonna and conium; according to Mr Dyer, it is particularly serviceable in chronic rheumatism, and painful affections of the stomach and uterus. . . . The common potato in a state of putrefaction is said to give out a most vivid light, sufficient to read by. This was particularly remarked by an officer on guard at Strasburg, who thought the barracks were on fire, in consequence of the light thus emitted from a cellar full of potatoes."[1]

The *Solanaceæ*, or Nightshades, comprise 900 species, of which we have only five in Britain. The genus *Solanum* has only two British representatives—*Solanum dulcamara*, a pretty climbing shrub, found occasionally in hedges; and *Solanum nigrum*, with an herbaceous stem. Both these plants, like the rest of the tribe, are strongly narcotic. The *Solanum dulcamara*, bitter-sweet, or woody nightshade, has a purple flower and bears red berries; the *Solanum nigrum*, or garden nightshade, bears white flowers and black berries. These plants can be identified botanically only by an examination of the leaves and berries. The active principle in both is an alkaloid, *Solania*, which is itself a poison, although not very energetic: two grains of the sulphate killed a rabbit in a few hours. According to Liebig, this poisonous alkaloid is formed in and around the shoot of the common potato when it germinates in darkness; but there is no evidence that the potatoes are thereby rendered injurious. Their noxious qualities are probably due to other causes.

The Wild Potato.—Having been so long familiar with the potato in a cultivated state, it is interesting to become acquainted with its appearance in its native localities and unaltered condition. "The wild potato," says Darwin, "grows on these islands, the Chonos Archipelago, in great abundance in the sandy, shelly soil near the sea-beach. The tallest plant was 4 feet in height. The tubers were generally small, but I found one of an oval shape, 2 inches in diameter; they resembled in every respect, and had the same smell, as English potatoes; but when boiled they shrank much, and were watery and insipid, without any bitter taste. They are undoubtedly here indigenous; they grow as far south, according to Mr Low, as lat. 50°, and are called Aquinas by the wild Indians of that part: the Chilotan Indians have a different name for them.

"Professor Henslow, who has examined the dried specimens which I brought home, says that they are the same as those described by Mr Sabine from Valparaiso, but that they form a variety which by some botanists has been considered as specifically distinct. It is remarkable that the same plant should be found on the sterile mountains of Central Chili, where a drop of rain does not fall for more than six months, and within the damp forests of these southern islands."[2]

"The potato (*Solanum tuberosum*) was generally cultivated in America at the time of its discovery; but it is only a few years since its native country has been ascertained with certainty. Humboldt sought for it in vain in the mountains of Peru and New Granada, where it is cul-

[1] Lindley's *Veg. King.*, 619-21.

[2] *Voy. H.M.S. Beagle round the World*, 285.

tivated in common with *Chenopodium quinoa*. Before his time the Spanish botanists Ruiz and Pason were said to have discovered it in a wild state at Chancay on the coast of Peru. This fact was doubted after the journey of Humboldt and Bonpland, but it was reasserted by Caldcleugh, who sent spontaneous plants from Chili to the Horticultural Society of London; and latterly Mr Cruikshanks confirmed it in a letter to Sir William Hooker, in which he says, —'This wild potato is very common at Valparaiso; it grows chiefly on the hills near the sea. It is often found in mountainous districts far from habitations, and never in the immediate vicinity of fields and gardens.' There is little doubt, therefore, that Chili is the native country of the potato; but Meyer affirms that he found it in a wild state, not only in the mountains of Chili, but also in the Cordillera of Peru."

Introduction into Europe.—It is asserted that Sir Francis Drake introduced the potato into Europe in 1573; but this is very doubtful, since it has also been ascribed to Sir John Hawkins in 1563; it is, however, certain that Raleigh brought it from Virginia to England in 1586; and it appears probable, from the learned researches of M. Dunal, that the Spaniards had established its cultivation in Europe before this time. It was first cultivated extensively in Belgium in 1590, in Ireland in 1610, and in Lancashire in 1684. Between 1714 and 1724 it was introduced into Swabia, Alsace, and the Palatinate; in 1717 it was brought to Saxony; it was first cultivated in Scotland in 1728; in Switzerland, in the canton of Berne, in 1730; it reached Prussia in 1738, and Tuscany in 1767. It spread slowly in France till Parmentier, in the middle of the eighteenth century, gave it so great an impulse that it was contemplated to give his name to the plant; the famine in 1793 did still more to extend its cultivation.

Distribution of the Potato.—According to Humboldt, the potato is generally cultivated in the Andes, at an elevation from 9800 to 13,000 feet; which is nearly the same elevation to which barley attains, and about 9800 feet higher than wheat. In the Swiss Alps of the canton of Berne, the potato reaches, according to Katsoffer, an elevation of 4800 feet.

"Towards the north of Europe, the potato extends beyond the limits of barley, and consequently that of all the cereals; thus an early variety has been introduced into Iceland, where barley will not grow. The potato degenerates rapidly in warm countries, yet the English have succeeded in cultivating it in the mountainous regions of India; but it is doubtful if it will ever succeed in the intertropical plains of Africa and America, where the temperature varies less than in Bengal. An elevation of at least 4000 feet seems to be necessary for the growth of the potato in tropical regions."[1]

Selecting Varieties for different Soils.—A remark of Mäers, that "some potatoes put out long filaments into the soil, others press their tubers so closely together that they show themselves above ground," suggests considerations in the selection of potatoes, which do not receive sufficient attention from farmers in search of seed-potatoes. On choosing seed, it is too often the case that the tuber alone is regarded, without reference to the habit of growth of the plant under ground; and many of those who profess to study the habits of the plant, confine their attention to the stem, foliage, and flowers, while the habits under ground of roots and tubers are entirely neglected. Now, when it has been ascertained that one variety "puts out long filaments into the soil," surely it is improper to plant that variety in strong soils, which necessarily oppose the penetration of tender filaments through them, when a light soil is just suited to that peculiarity of growth. Mr John Speir writes that on his farm, where all potatoes are grown for seed purposes, coarse, degenerate, or foreign varieties are regularly dug out every season *before the crop is matured.*

Cultivators should take the trouble of investigating experimentally the peculiar growth under ground of different varieties of the potato-plant, so that it may be cultivated in soil suited to its nature, and thereby return the largest yield of sound, wholesome, and palatable tubers.

Varieties in Use.—The varieties of

[1] Johnston's *Phys. Atl.*,—"Phyto.," Map No. 2.

potatoes now in use are very numerous. Several hundreds indeed there are, and every year adds to the number.

The principal kinds planted now are the various sorts of Regents for early sale, while Magnum Bonums and Champions form the main crop. More interest is taken in rearing new potatoes by hybridisation, and new varieties of considerable promise are offered to farmers every season.

The influences of soil and climate introduce variations in the different sorts, but the multiplicity of varieties is due mainly to the raising of new sorts from the seed. It has been found that an occasional new variety successfully resists disease for a few years, and this, of course, has given a great stimulus to propagation from seed.

Good Potatoes.—A good potato is neither large nor small, but of medium size; of round shape, or elongated spheroid; the skin of rough and netted appearance, and homogeneous; and the eyes neither numerous nor deep-seated. Smooth potatoes are almost always watery and deficient in starch.

Some kinds of potatoes, as Kidneys and Regents, are fit to use when lifted, but other kinds improve with keeping, and are best in spring.

The *intrinsic* value of a potato, as an article of commerce, is estimated by the quantity of starch it yields on analysis; but, as an article of domestic consumption, the *flavour* of the starchy matter is of as great importance as its quantity. Almost every person prefers a mealy potato to a waxy one, and the more mealy it is usually the better flavoured. The mealiness consists of a layer of mucilage immediately under the skin, covering the starch or farina, which is held together by fibres.

Light soil yields a potato more mealy than a strong soil; and a light soil produces a potato of the same variety of better flavour than a clay soil. Thus soil has an influence on the flavour, as well as on culture; and the culture which raises potatoes from soil which has been dunged for some time, imparts to them a higher flavour than when grown in immediate contact with dung.

The destructive fungoid disease known as *Peronospora infestans* is dealt with in connection with other "Fungoid Diseases" of crops.

The Boxing System of preparing Potato-sets.

Mr John Speir, Newton Farm, Glasgow, thus describes the system of preparing the potato-sets in boxes:—

This system was introduced for the purpose of maturing the potato crop sooner than could be done by the ordinary manner of planting. It is said to have been first introduced in Jersey, where it is extensively practised. Along the whole of the Firth of Clyde it is more or less in use on all the earlier farms, and more particularly in the neighbourhood of Girvan it has been carried to such an extent that several farmers there have upwards of a hundred acres of potatoes all planted from boxes.

Boxes.—The boxes may be of any convenient size or shape, provided they are not too deep, the size in most common use being about 2 feet long, 18 inches broad, and from 3 to 4 inches deep. Each box generally holds from 3 to 4 stones of potatoes, the former being about the average. The boxes are made of ½-inch deal, and have pins 1 inch square and 6 inches high nailed in each corner. The top of these pins therefore projects from 2 to 3 inches above the edge of the box. These pins are strengthened in their position by having another bar, 1 inch square, nailed across the ends, and reaching from the top of the one corner pin to the top of the other. These cross-bars also serve as handles for carrying the boxes, besides being in other ways useful.

Tubers Boxed.—The potatoes used may be of any variety, but where early maturity is the main object, only the earliest varieties are used. Those most in demand at present are Don, Sutton's Early Regent, Beauty of Hebron, Goodrich, Dalmahoy, and Red Bogg, in the order here enumerated. Only small or medium-sized potatoes are used, all over 1¼ inch and under 1¾ inch in diameter being considered suitable.

Cut Seed Unsuitable.—Cut seed cannot so satisfactorily be used, because the sets remain so long in the boxes, and such a quantity of the moisture evapo-

rates from the sets that they ultimately shrivel up, and become so dry that the bud never starts into life.

Boxing the Seed.—The seed may be placed in the boxes any time between the end of July and the New Year, the most suitable time being probably September or October. At the latter end of July, all potatoes which are at that time dug and of too small size for table use, may at once be put into boxes, and thus preserved for seed to the following spring. In the boxes they keep with very little loss, even although quite soft and green when put in, whereas if stored in the ordinary manner all would be lost.

Storing Boxes.—During autumn the boxes may be stored in any unused barn, byre, shed, or other house which is rain-proof. The boxes are placed in tiers one above the other to any convenient height, the corner pins and cross-bars of the one box supporting the weight of those above, the extra height of the pins over the depth of the box giving sufficient room for the ventilation of the tubers and growth of the sprouts.

When cold weather sets in, the boxes should be removed to some position where they will be free from the effects of frost. Very many are stored on the joists of byres, bullock-houses, &c., where the heat from the animals is always sufficient to start germination, and keep out most frosts. Others, again, are stored in empty cheese-rooms and other houses specially built for the purpose, which are provided with artificial heat in the shape of a stove or other heating apparatus. It is not often that the heating apparatus requires to be called into use, but it is almost a necessity against occasional extreme frosts, and it comes in handy for pushing on late boxed or tardy germinating tubers.

Planting Boxed Seed.—Planting is generally begun about the first of March, and in the most favoured localities a little earlier. Before this system was adopted, the localities which now use it generally began to plant in January or February, but now there is nothing to be gained by beginning so early, and much may be lost by frost cutting off the haulms of the plants after they have come through the ground. Previous to planting, the boxes with the potatoes in them are removed to the field in carts, and distributed along the side of the land, being placed in much the same way as sacks of cut potato-sets are put down before planting begins.

The *sprouts* at this time may be from 2 to 4 or more inches long, but instead of being white and brittle like those seen on potatoes in an ordinary pit, they are blue and tough, and not at all readily broken off. The tubers are generally removed from the boxes by light trowels, and carefully deposited in hand-scoops of such a size that a woman or boy can easily carry them full in one hand, while the potatoes are picked from them and planted with the other. The removal of the potatoes from the boxes to the scoops is generally the work of one or more careful persons, as they will not bear rough handling, while others carry them when filled to the planters. If the sprouts are comparatively short, the sets may be transferred from the boxes to the planters' aprons in the usual way of carrying cut potato-sets; but by doing so the plants get much rougher handling, and a few are always more or less damaged.

Seed per Acre.—The seed required to plant an acre on this system varies very considerably according to the size of the potatoes used. Where the smallest size of potatoes are planted, 30 boxes containing from 3 to 3½ stones will be found amply sufficient, even where two-foot drills are made, and close planting in the drill is followed. If, however, the potatoes are larger, say about 1¾ inch in diameter, 50 boxes of the same capacity may not be more than sufficient. In the former case, therefore, 12 cwt. or so will be sufficient for an acre of land, while a ton may be required in the latter.

Advantages of the System.—The reasons of the success of this system appear to be,—1st, the gain in time by the sets being sprouted before being planted; and 2d, the long period of drying to which the seed is subjected to in the boxes so ripens the potatoes and alters the constitution of the plant, that it matures its tubers the following season much quicker than if it had been preserved and planted in the usual way.

A crop from seed which has been boxed is usually ready to lift *three weeks* earlier than one grown from similar seed which has not been boxed. The produce is, however, generally believed to be a little less than that grown in the ordinary way, but the higher price at that time more than makes up for the lessened crop and extra expense incurred.

In the forcing of rhubarb, hyacinths, narcissi, spiræa, &c., the plants or bulbs must all be rested a certain time before growth will begin, no matter what heat and moisture are used; and in the case of the potato, the dry-keeping in the boxes instead of the damp-keeping in pits, appears to have a somewhat similar effect, as more time is gained than is accounted for simply by sprouting. An unsprouted crop may indeed look as far forward as a sprouted one, and yet not exhibit half the weight of tubers.

Raising New Varieties of Potatoes.

New Varieties Resisting Disease.—Ever since the well-known potato disease (*Peronospora infestans*) manifested its effects with such baneful influence, the raising of new varieties has been incessantly pursued, because it was found that new varieties withstood the disease better than most old ones. It has, however, been found that potatoes which were almost absolutely proof against disease when first introduced, have in course of time gradually fallen a prey to it, until in the end they had to be discarded altogether. Since the introduction of the Champion and Magnum Bonum, this search after new disease-resisting varieties has received a marked impetus, and as these varieties likewise began to show evident signs of decay, the desire for new varieties continued to increase. In order, therefore, to stimulate private energy in the direction of introducing new and improved varieties, we produce here the following description of the process, prepared for us by Mr John Speir, Newton Farm, Glasgow. The illustrations used in describing this process are taken (by the kind permission of the publishers, Messrs A. & C. Black) from Balfour's 'Elements of Botany.'

Potato-seeds.—As most people know, new varieties of potatoes are raised from the plum, as it is popularly called. The plum holds the same relation to the potato-plant as the apple does to the apple-tree. It is the fruit, and, within, the fruit contains the seeds. The seeds of the apple or orange, I presume, every one is familiar with. The potato also, like them, has its seeds contained in a mass of pulp, which, however, unlike the apple or orange, is not of such a pleasant taste. Hence the seed of the potato is not so well known.

Seedless Varieties.—Some varieties of potatoes do not throw up flowers, and therefore cannot have plums. Seed must thus be looked for only on those varieties which have flowers. Again, all varieties which have blossoms do not have plums, as some appear unable to set a single bloom, unless on very rare occasions. With plants as with animals, in-breeding, if I may so express it, although not at first very hurtful in its effects, is very liable if persisted in to have a deleterious influence on either plant or animal; the stamina of both evidently becoming so reduced, that they fall a ready prey to disease.

Cross-fertilisation.—The methods which nature has adopted in plants, not exactly to prevent self-fertilisation, but to favour cross-fertilisation, are numerous, curious, and very interesting. Darwin proved beyond doubt that certain plants if self-fertilised would attain a moderate size; if cross-fertilised from plants growing alongside of them, they would attain a much greater size, and if fertilised from plants of the same variety grown on different soil, some miles away, their size would be still further increased.

These facts are of very great importance to the raiser of new varieties of potatoes. In fact, it is principally on cross-fertilisation that he relies for success. A new and quite good enough potato may be raised from seed where no intentional cross-fertilisation has been done, but the chances are that such a plant has been self-fertilised, or cross-fertilised by a plant of its own variety. The consequence will be that a much smaller proportion of the seeds sown will produce plants having vigorous constitutions, than if a different and improved

variety from a dissimilar class of soil had been used in fertilisation.

Male and Female Organs.—Among plants, as among animals, there are male and female organs, which in most plants are situated in the same flower. On some, however, the male blossoms are on one part of the plant and the female ones on another, while in others the males and females are on separate plants.

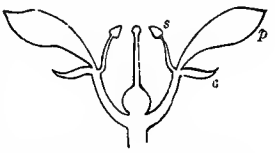


Fig. 323.—*Section of a flower.* c, Calyx. p, Petal. s, Stamen.

In fig. 323 is shown a section of a flower, in which *c* represents the calyx or short green hard leaves at the base of most flowers, *p* is the petal or flower proper, *s* is a stamen, of which there are two shown on either side of the central figure: these are the male parts of the flower, while the centre part is the pistil or female part.

Fig. 324 is a horizontal section showing the organs of fructification of the potato, where the calyx or outer scales are five in number, and the blossom proper contains five petals, the one overlapping the other. Inside the circle of petals are shown five stamens, and inside that again the pistil, with seed-pod at its base.

Fig. 324.—*Horizontal section.*

In fig. 325 is shown a vertical section of a potato-blossom, in which *c* represents the calyx; *p*, the petals, or bloom proper; *e*, the stamens; *s*, the pistil; and *o*, the ovary or seed-vessel. At a certain age the stamens throw off from their top a very fine powder, which is called pollen.

Fig. 326 represents a stamen in the act of discharging its pollen, which in some cases is thrown out through slits in the anther, *a*, or top part, while in others, like the potato, it comes out through holes or tubes.

Fig. 327 is a pistil with pollen-grains on the top. The uppermost part, *stg*, is called the stigma, with pollen-grains, *p*, adherent to it, sending tubes, *tp*, down

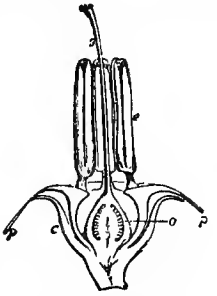


Fig. 325.—*Vertical section of a potato-blossom.* c, Calyx. p, Petals. e, Stamens. s, Pistil. o, Ovary.

Fig. 326.—*Stamen discharging pollen.* a, Slits in the anther. p, Pollen.

the conducting tissues of the style, *styl*; the ovule is *o*; while in (2), *p* is a pollen-grain separated, and *tp* its tube.

Fig. 328 represents a pollen-grain very much magnified, showing three points where the tubes come out, one of which is considerably elongated.

Fig. 329 is a very much magnified vertical section of the style and stigma of the pistil, showing two pollen-grains on the top, throwing out their protruding tubes which descend to the ovules.

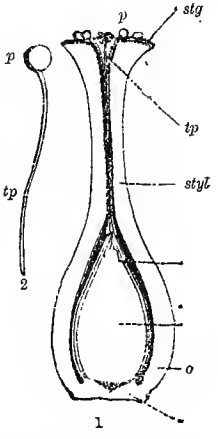


Fig. 327.—*Pistil with pollen-grains on top.* (1) *stg*, Stigma; *p*, pollen-grains; *tp*, tubes; *styl*, style; *o*, ovule. (2) *p*, pollen-grain; *tp*, its tube.

Process of Cross-fertilising.—When it is wished to cross-fertilise a potato-blossom, the flower is held steadily in the left hand, while with the right the stamens, or male parts of the flower, are cut away with a pair of fine-pointed scissors, or a sharp and fine-pointed knife. These are the parts marked *s* in fig. 323, and *e* in figure 325, all of which must be destroyed soon after the bloom has expanded. Three or four days afterwards, on a bright clear day, the bloom of some plant which it is intended to

cross with the one on which we have operated, is taken, and the pollen scattered on the stigma of the mutilated plant. If the anthers are ripe, this can be very readily done by bending the stamens back with the tip of one of the fingers, then letting it spring forward again, when the pollen will be thrown off. Another way is to brush them with

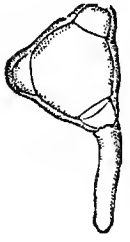


Fig. 328.—*Pollen-grain magnified.*

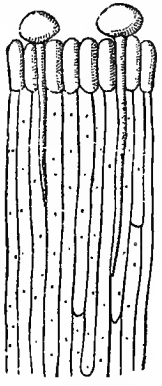


Fig. 329.—*Vertical section of style and stigma magnified.*

a dry feather or small camel-hair brush, which takes on a certain amount of the pollen-grains, which by drawing across the stigma are in part conveyed to it. The top of the stigma always contains more or less glutinous matter, on which the pollen-grains readily stick.

If it is desired to make the cross-fertilisation very accurate, and to be certain that no other pollen-grains are conveyed to the stigma by insects or the wind, the bloom may be tied to a stake and covered with a small fine canvas bag, or a glass globe.

For the purpose of raising seedling potatoes these precautions are, however, unnecessary. It may be here mentioned that when a potato-bloom has been only a day or so opened, the organs of fructification then have a more or less greenish tint, the colour of the stamens and pistil being as yet only partially developed;—that is *the time to cut away the stamens.* At first the stamens are much shorter than the pistil, but as they approach maturity they become more of one length.

Fig. 330 represents the ripened plum, while fig. 331 is one cut across the centre, showing the seeds inside. According to variety the size of the plum may vary from that of a cherry to the size of a

Fig. 330.—*Potato-plum.*

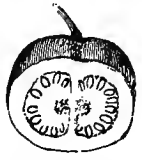


Fig. 331.—*Plum cut, showing seeds inside.*

damson plum. Fig. 332 represents a magnified seed.

Marking Fertilised Plum. — In order that the plum of the flower on which cross-fertilisation has been practised may not be mistaken for some self-fertilised one, each bloom as operated on should be tied to a stake, to which a label is affixed, giving the name of parent, date of cutting the stamens away, date of fertilisation, and name of the variety used for crossing. Flowers thus labelled are easily found, as the white stakes and labels are good guides, and worth all the labour for that alone.

Fig. 332.—*Potato-seed magnified.*

Ripe Plums. — When the plums are thoroughly ripened, they should be gathered and the seeds separated from the pulp. The ripening stage is easily known, because as maturity is approached the stalk bearing the plum first withers, then gradually shrivels up, ultimately becoming so dry that it breaks, when the plum drops on the ground. If left to themselves the plums soon rot, the hard seeds alone remaining fresh, and if these are kept moderately dry and out of the reach of birds they remain dormant till spring, when they begin life anew.

Securing and Storing Seeds.—For experimental purposes, however, the plums should be cut up when ripe, and the seeds picked out and dried under cover, preferably on a window-sill, or in a dry greenhouse; and when dried sufficiently to keep during the winter, they may be stored away in any dry situation. Instead of thoroughly drying the seeds, they may be mixed with dry earth or

sand, and thus stored during the winter, the whole (the earth or sand and seeds) being sown in a seed-bed in spring.

The plums may even be treated in this way, by surrounding them with dry earth and letting them so remain till spring, by which time the pulp will have rotted or dried up, leaving the seeds more or less mixed up with the soil. Either plan may be adopted successfully enough, but personally I prefer the first.

Sowing the Seed. — In spring the seeds may be sown under glass any time during February, March, or April, the young plants being kept under glass, particularly at nights, until all risk of frost is gone. If no glass is at hand, the sowing of the seed should be deferred till April or May, when it may be sown thinly on any garden soil in a small bed by itself.

The Young Seedlings. — In the month of May the young seedlings should be planted out, in rows not less than 20 inches apart, with 1 foot between the plants. If the seeds have been raised from strong-growing varieties such as Champion or Magnum Bonum, the seedlings will be all the better of more space; while if they are from smaller-stemmed varieties, such as Myat's Kidney, &c., they can do with less space. If the ground is dry-bottomed, they should be planted in the bottom of the drills, so as to give a suitable opportunity for thoroughly earthing them up. But if the young plants are likely to run any risk of being soured at the root by heavy rain they will be better planted on the flat, the earthing up in either case being done as the plant grows. If moderately manured, and kept in good clean order, the plants will soon cover the ground, the time they will take to do so being not very much longer than if ordinary potato sets had been used.

Lifting and Selecting.—At the end of October, or beginning of November, storing should commence, when the experimenter's real difficulties begin. When storing, all varieties of a very bad shape, coloured, or partly coloured skins, or bad colour of the flesh, should at once be rejected, as their preservation will likely only lead to trouble and expense, with very little chance of any corresponding gain.

The first year all plants not positively bad should be preserved, and a note kept of any peculiarities of growth, shape, colour, size, or productiveness of each.

Storing.—With many experimenters, the separation and preservation of, it may be, several hundred varieties, has been a serious drawback to their continuing the search for improved kinds. This, however, may be easily overcome in the following manner: A number of ordinary drain-pipes should be procured, and, for the first year's crop, the smaller the bore the better. One end of the pipe having been closed by a small wisp of hay or straw, the tubers of each variety are put in along with their number, when another small portion of straw, or piece of turf from an old pasture, is put on the top, then another variety, and so on till the tiles are all filled. The first year each tile may hold several varieties, whereas the second year one variety may be more than enough for one narrow-bored tile, in which case two may be used, or larger-sized ones procured. Small strips of wood, coated with white lead, and marked with an ordinary lead pencil, serve for numbering each lot; or pieces of tin, with the figures stamped on, may be used, if a set of figure stamps can be procured. After packing, the tiles may be built up in a heap, and covered as if it were an ordinary potato-pit, when they will require no further attention until planting-time in the following spring.

Period of Development. — It is a common belief that seedling potatoes require several years to form ordinary-sized tubers. Such, however, is not the case, as even the very first year many of the varieties may yield potatoes of a medium size and upwards, while the second year all worth preserving should have one or more full-sized potatoes.

Second Year. — When the potatoes are taken out of the pit or clamp the following spring, they may be planted in the usual way, and at the usual time, no particular advantages of soil, situation, or manure being given, in order to facilitate the elimination of the worthless varieties as soon as possible.

At the end of the second year, they should again be stored in tiles as for-

merely. This time each variety will require one or more tiles for itself.

The selection must this year be much more searching than the former one, and instead of rejecting only what appeared to be positively bad varieties, those only should be kept which show some good points, or other noted peculiarity.

If notes have been taken during both the growing seasons of the robustness, earliness, lateness, liability to disease, or other peculiarity of the plants, the grower will be greatly aided in his selection.

Third Year.—The third year, only tubers should be kept which show positively some good points, all others being laid aside for consumption. In this way the list will be gradually reduced each autumn and spring, as many good cropping varieties will be found to be bad keepers. A large portion of the plants will thus be rejected every autumn, with a smaller portion in winter and spring, as some which have stood the test of several years may be found not to keep well, or to cook badly.

Retain only Superior Varieties.—After the fourth year, no variety should be kept which the *grower does not consider better than those already in cultivation*, because to propagate any that are not superior to those already in use, undoubtedly *in the end will be sure to bring pecuniary loss on the grower*. It is on this rock that most raisers of new varieties wreck themselves. They find it so difficult to cast away seedlings on which they have expended so much time and care, and to do so appears to them like sacrificing their own children. For want of courage to apply the pruning-knife severely enough, they continue, in the hope that they will yet improve, to propagate and keep in existence a large number of varieties which no one but themselves thinks worth devoting attention to. The consequence is, that in the end they become overwhelmed with varieties which are of no commercial value, and they throw up the whole thing in disgust.

Need for New Varieties.—At present there are more than enough varieties of potatoes in commerce or cultivation. Unfortunately, however, there are only a few good ones, so that the field for research is not only a wide, but a very varied one. The qualities requisite to make a first-class early, medium, or late potato are so many, and even good varieties retain these for such a short time, that there is likely always to be a demand for really first-class varieties. Although the personal attention requisite may be too heavy a drag on the ordinary farmer, who already has as much to do as he can well accomplish, the raising of new varieties of potatoes might well form a very suitable and interesting pastime for a proportion of our farmers' sons and daughters, as well as older farmers and gardeners, who have the time to spare.

HORSES IN SPRING.

The feeding and general treatment of farm-horses in spring is, in the main, a continuation of the methods pursued in winter. The various systems of feeding and management are so fully discussed in Divisional vol. ii. pp. 392-420, that little need be said here.

As the spring advances and the days lengthen, more work has to be accomplished by the horses than fell to their lot throughout the winter. The allowances of food must therefore be a little more liberal. In particular the proportion of the more strength-giving and staying foods, such as oats, should be increased, the object being to make the horses strong and active rather than high in condition, and soft and liable to excessive perspiration.

Great attention should be given to the grooming as well as to the feeding of horses that are hard worked in the spring months. When they return to the stable, most likely wet and "steaming" with perspiration or rain, or both, they should at once be well rubbed down with

a handful of straw. Then when dry they should be combed and well brushed. At night their legs and feet should be cleaned of any clay or earth adhering to them, and a comfortable bed, as well as a plentiful and wholesome supper, provided for them.

A nightly or occasional feed of raw swedes will be relished by work-horses in spring; and many give a warm mash, consisting perhaps of boiled barley and oats and turnips, at least once a-week.

Good hay is preferable to oat-straw for hard-worked horses in spring. The midday meal in the height of spring work, when the horses are hard driven, and need rest as well as food, should consist largely of such concentrated sustaining material as oats. The horses speedily consume a feed of bruised oats, and thus have time for rest. Hard-worked horses should be disturbed as little as possible during the hours allotted for rest and feeding, so that they may return to their work fresh and vigorous.

THE FOALING SEASON.

In connection with the management of horses in spring, *foaling* is of course the chief subject of consideration. The foaling season is an anxious time for the owners of brood mares. The risks in foaling are greater than the calving risks, for the bovine race is hardier than the equine. With moderate skill and timely attention, however, serious losses in foaling are not likely to be of frequent occurrence.

Insurance against Foaling Risks.—Several insurance companies provide special facilities for insurance against losses in foaling, and farmers are very prudently taking advantage of this provision of safety. The cost of insurance is comparatively small, and the sense of security it affords to the farmer is very comforting.

Abortion in Mares.—Abortion in mares, as in other animals, is often difficult to account for. Some mares are predisposed to it by disease, or by malformation of the parts specially involved in generation. In the large majority of cases, however, abortion in the mare may be attributed to injury inflicted in one form or other. A fright, chasing, hurried driving, a kick from another horse, overexertion at work, a shake between the shafts of a heavily loaded cart or waggon, are amongst the more violent actions liable to cause abortion. But it may also be induced by serious illness, improper feeding, especially with forcing food, exposure to wet stormy weather, eating poisonous plants, consuming frosted food, drinking an excess of cold water, &c.

The greatest possible care should be exercised all through the period of pregnancy, alike in feeding and working the mare. She should be fed liberally but not excessively, for overfeeding may itself cause abortion. It is a well-known fact that overfed mares are liable to produce small foals, and the tendency to this is still greater when the overfed mare is an idle animal, kept perhaps solely for showing and breeding purposes.

When abortion does occur, the mare should be kept apart from other mares in foal until they have produced their young. And these other mares should not be allowed access to the spot where the unfortunate mare aborted.

Working Mares in Foal.—There is considerable difference of opinion and practice amongst farmers as to the working of mares up to foaling-time. Mares accustomed to steady farm-work may safely enough be kept at the lighter kinds of work up to within a few days, or at most a week, of the expected date of foaling. Indeed, if the work is not too heavy, and she is not overdriven, the mare will be all the better of the exercise. Harrowing is very suitable farm-work for mares near foaling; and they also may be employed safely in ploughing if driven at an easy pace, and not yoked with a restless ill-natured animal, or in the care of a reckless ill-tempered man. Carting is unsafe work for mares heavy in foal, and should be avoided if at all possible. The shafts may inflict serious injury, and backing a loaded cart often brings on dangerous abortion.

Foaling-box.—About ten days before the date upon which the foal is expected, the foaling quarters should be prepared. A large loose-box or shed, apart from the other horses, is best adapted for the purpose; and the compartment should be comfortably littered, free from unpleasant

smells, perfectly free from draughts which could play either upon the mother or youngster, yet be so ventilated as to maintain the atmosphere in pure, equable, and wholesome condition. The means of ventilation should thus be placed some little distance above the head of the mare when she is standing, perhaps in the roof of the house. Where a special compartment such as this does not exist, or cannot be provided, a fairly comfortable foaling-box may be improvised by removing a travis and turning two stalls at one end of the stable into one loose-box. The foaling compartment should always be large enough to allow the mare to turn herself with ease at any part of it without incurring the risk of crushing the foal in so doing.

Watching Mares at Foaling.—It is very desirable that an eye should be kept on the mare night and day at foaling-time. Mares carry their foals from 330 to 360 days, eleven months being the time most generally "reckoned." They are by no means punctual however, and very often a mare has to be watched for a week or ten days, occasionally even longer. This duty may be irksome, but it is better to endure it than run the risk of losing a valuable foal, and perhaps also a still more valuable mare.

Symptoms of Foaling.—One of the surest signs of the approach of foaling is afforded by the udder. It of course becomes large, and a fluid begins to ooze out of the teats. At first the fluid is thick, dark-coloured, and sticky, but it gradually becomes white and milk-like. When this change has set in the foal may be expected within twenty-four hours, and the mare should not be left for a moment till the event has taken place.

Less definite indications of the completion of the period of pregnancy are the drooping of the belly, the swelling of the external organs of generation, and the flanks sinking inwards. The mare becomes dull and disinclined for exercise, while the movements of the foal will be seen to grow more distinct and active.

Assistance in Foaling.—Mares seldom need assistance in foaling. When aid is required, great skill and care must be exercised in rendering it. In cases which threaten to be protracted, or show any unusual and dangerous symptoms, the veterinary surgeon should at once be called in. Rarely, indeed, is a case of difficult foaling carried through successfully by any except an experienced and specially trained man in obstetrical work amongst farm animals.

Difficult Foaling.—If the mare has gone the full time of pregnancy, any exceptional difficulty in foaling is more than likely to arise from the foal lying in an abnormal position. The head and fore-feet should come first, the head resting upon the two fore-legs, just as in the case of a calf. If the labour pains are protracted without any apparent or sufficient progress, the hand should be smeared with oil or lard, and gently inserted to discover the position of the foal. If it is in its natural position as indicated, a little time will likely complete the process. If the foal is not yet in the passage, give the mare more time, and if necessary make another examination. If the foal is not presenting itself in the usual position mentioned, it may be necessary to adjust it, or at any rate to make some alteration in its position before birth can take place.

But this delicate work requires so much skill that, as already stated, it cannot be safely intrusted to any but a well-trained veterinary surgeon. If at all possible, have the veterinary surgeon at hand in such cases. If this is impossible, obtain the advice and assistance of the most experienced person within reach. Do not be too hurried in assisting the mare. Watch carefully, and assist nature when assistance seems likely to be useful. The mare needs more skilful and more careful operating than the cow in difficult parturition.

Such a case as this, however, is quite exceptional. As a rule, all that need be provided for the mare is a comfortable and cleanly compartment, with just a little less than the usual amount of food given to her when at work. The rest will, in most cases, be accomplished by nature.

Reviving an Exhausted Mare.—If the mare should seem to be weak or exhausted she will be revived by a drink of milk-warm oatmeal gruel, with the addition of a little brandy, perhaps about three ounces. In protracted cases this may have to be repeated at intervals.

Support to Mare's Belly. — Brood mares which have produced several foals are liable, when well up in years, to show a large extension of belly. For the sake of appearance as well as comfort to the mare, it would be well in extreme cases to support the belly for a time after foaling with wide soft bandages, wrapped several times round the body.

Mare's Udder.—Inflammation sometimes occurs in the udder of a mare being sucked. The udder is found to be hard and hot to the touch, and evidently painful to the mare. Foment the udder with warm bran-water, rub gently, and draw away a little milk at frequent intervals. It may be necessary to remove the foal for a few days and give the mare a dose of physic. Do not give medicine unless the foal is taken away from the mare for the time. A change of diet and low feeding for a few days may give relief. In a bad case, lose no time in calling in the veterinary surgeon.

After Foaling.—When it is seen that the foaling has been completed successfully, and the mare and foal on their feet, a drink of warm gruel, made of oatmeal and water, or oatmeal, bran, and water, should be given to the mare, some sweet hay being placed in the rack. The two should then be left in solitude for a little time. As a rule they speedily become accustomed to each other's society, and only in exceptional cases is any further interference required, either on behalf of the foal or the mare.

Cleansing.—In ordinary circumstances the "after-birth" will come away of its own accord very shortly after delivery. If it has not done so within at most a couple of days, it will most likely have to be removed by the hand. This must be done gently and carefully; and if the after-birth has begun to putrefy, the passage and uterus should be cleansed and disinfected by alternate injections of warm water and diluted Condy's fluid.

After-straining.—If the mare should continue to strain heavily for some time after birth, it may be assumed that all is not well with her, and that the advice of the veterinary surgeon would be useful.

Attention to the Foal.— The foal needs attention the moment it is born. First see that it has broken through and freed itself from the enveloping membranes, so that respiration may set in. Then examine the umbilical cord, or navel-string, and see that it has been severed, and that there is no serious bleeding. The navel-string is usually snapped in the act of foaling, but occasionally, particularly if the mare is lying and unable to rise, it may not be broken. In that case, the attendant should at once tie a piece of twine around the navel-string at two places, about two inches apart, and then sever it between the tyings.

Reviving Weak Foals.—It occasionally happens that a foal, although still living, is to all appearance dead when born. In this case, efforts should at once be made to induce respiration. A moment's delay may result in the extinction of the vital spark, which, with prompt action, might be fanned into active life. Sponge the mouth, face, and nostrils with cold water, blow hard upon the nostrils, smack the sides of the chest smartly with a cloth, rub the body well—all this as quickly and deftly as possible, but without violence. In all probability respiration and breathing will begin immediately, and no further trouble will be encountered. Cold water dashed sharply against the chest is sometimes successful in reviving foals.

Weakly foals will be all the better of a little extra attention at the outset, in the way of rubbing and drying with a woollen cloth. The limbs as well as the body should be well rubbed. It helps to promote circulation and give strength to the young creature.

Rearing Foals.

Foal-rearing demands the most careful attention from the breeder. Foals are not so robust as calves, and are more subject to injury from cold and wet. In the great majority of cases, the foal is reared almost entirely on its mother's milk for a period ranging from four to six months. Unless exceptional circumstances have arisen—unless from some cause or other the mare becomes an inefficient or unkindly nurse—it will rarely happen that the mother and offspring require any special aid or interference until weaning-time arrives.

Coaxing a backward Mare.—Occa-

sionally it does happen that a mare, most likely in cases of the first foal, will not admit the youngster to the udder. The cause of this may be nervousness or ill-temper, and, as a rule, a little kindly coaxing will do all that is required. Let the mare see that you mean no harm to her or her foal, speak gently to her, give her a drink of milk-warm gruel, and a mouthful of sweet hay. Leave the two together for a quarter of an hour, and if she should once begin to lick the foal there will be little fear of her objecting to its sucking. If you find still that she is not licking the foal, sprinkle a little flour over its back, and contrive gently to bring the presence of the flour under her notice.

Try hard with coaxing before resorting to other measures. A mare in such circumstances is inclined to be suspicious, and will watch your conduct very closely, and with wonderful intelligence. Kindliness and patience are valuable attributes in the attendant upon brood-mares. In cases such as have been indicated, there is ample scope for the exercise of both virtues. In nine cases out of ten they will accomplish the object.

Intelligent Treatment of Mares.—But if it should unfortunately happen that by gentle coaxing the mother cannot be induced to admit the foal to the teat, other measures of a firmer kind must be resorted to, still taking care that in all measures, however drastic, calmness and good temper are displayed. Fussiness and irritability should never be witnessed in the foaling-box. The mare would quickly detect such behaviour, and would become the less tractable in consequence. Be kind but firm with the mare, giving her clearly to understand that, while you are not to abuse her, you mean to make her submit to your will. Depend upon it she will not be slow to read your meaning. The intelligence of horses is wonderful. We would often be more successful than we are in the management of contrary animals if we treated them more rationally than we do, and paid more respect to their intelligence and sensibility. In a very special sense these remarks apply in the foaling-box.

The attendant at foaling-time should be a man with whom the mare is familiar, and upon friendly terms. The presence of strangers is liable to make the mare suspicious, and therefore restless.

Extreme Measures with Obstinate Mares.—Sometimes, when coaxing has failed, confinement of the two in a dark loose-box will be sufficient to bring mother and foal into friendly relationship. If this again should fail, hold the mare and allow the foal to suck. If the mare is vicious, she may attempt to kick the foal. In that case, hold up her near fore-foot, and if she is persistently obstinate and mischievous, it may be necessary to put the twitch on her nose, and perhaps administer a little sharp chastisement with the whip, taking care that no harm comes to the foal in the excitement. These extreme measures will very seldom be necessary, and should never be resorted to until all the more gentle efforts have been tried in vain.

Admit the foal to the udder five or six times a-day, and each time, before resorting to harsh measures, do your very best to induce her to let it suck willingly. Most likely two days of such treatment will bring the mare to a sense of her duty. In rare cases of obstinacy, the interference may have to be continued for a whole week.

Beginning the Foal to Suck.—The foal will often be very awkward in its first efforts to suck. Do not attempt to assist or direct it. Keep the mare quiet, and let the youngster feel its way itself. The instincts of nature will be its best teacher, and it will soon learn how to proceed. The mare's udder may be hard, and the teats dry. If so, rub the udder with the hand, and draw away a little milk, leaving the teats moist, so as to lead on the foal in its first attempt to suck.

Extra Food for Foals.—Many experienced breeders begin very early to give extra food to foals, even where there is no very obvious deficiency of milk on the part of the mother. In some cases mashes, consisting of scalded oats, bran, and water, with perhaps a little boiled beans or peas, and a sprinkling of salt, are given to the foal before it is quite two months old. To induce the foal to eat this extra food, it may be taken away from its mother for an hour or two each day, and the food then given to it. In

its first few months the growth of a foal may be easily and effectually stimulated; and this should certainly be done, with due care, of course, not to overdo the young animal in any way. It is a common experience amongst breeders that a pint or two of beans, or other similar food, given to a foal, will do more to promote the growth of the animal at that stage than double the quantity consumed two years afterwards.

Nursing Motherless Foals.—When a mare dies and leaves a living foal, or when a mare is unable to rear twin foals, or even to rear one, the best course for the sake of the foal is undoubtedly to procure a nurse-mother. No system of hand-rearing is quite equal to the mare's udder; and especially in the case of an exceptionally valuable foal an effort should certainly be made to procure a nurse-mother. This, however, is usually difficult to obtain, and, as a rule, foals that cannot be suckled by their own mothers have to be reared by the hand.

Rearing Foals by Hand.—For the young foals cow's milk is the next best food to the mare's milk. If the foal is newly born, the milk must at the outset be poured gently into its mouth. A feeder may be improvised by taking a teapot or kettle with small spout, and wrapping two or three folds of a cloth around the spout to make it soft and comfortable for the foal's mouth. The foal will suck away at this, but take care not to let the milk run into the foal's mouth too rapidly at first. As a protection against this the aperture in the spout of the feeding vessel should be very small, perhaps not more than an eighth of an inch.

By the time the foal is a week or ten days old it may be taught to drink the milk out of a pail, just as the hand-fed calf drinks its milk. And the method of teaching a foal to drink in this way is very similar to that pursued in learning the calf. Give the foal your fingers to suck, and gently lead its head into the pail until it draws up milk between the fingers. By introducing the foal to the milk a few times in this manner it will readily learn to drink of its own accord when the pail is placed before it.

Cow's Milk for Foals.—Cow's milk, as we have said, is the best food on which to rear a foal for which mare's milk cannot be obtained. For some time at the outset at any rate, the milk should be new and warm as it comes from the cow. Many experienced breeders think it desirable to dilute the milk with warm water and a little sugar. The foal should get little at a time, and be fed four or five times a-day. It may not be convenient to milk a cow so often as five times a-day, and therefore, at least for two of the meals to the foal, the cow's milk may have to be kept for two or three hours. In this case the milk should be heated to about the temperature of new milk by the admixture of a little hot water in which a very little sugar has been dissolved. When it is desired to give the milk undiluted, the best way of heating it is to insert the tin vessel holding it into another vessel containing hot water.

Bean-milk and Cow's Milk for Foals.—It sometimes happens that foals do not thrive satisfactorily on cow's milk alone. In this case the substitution of bean-milk for perhaps about one-half of the cow's milk may be tried. The bean-milk is prepared by boiling the beans almost to a pulp, removing the shells and pressing the pulp through a fine hair-sieve. The result is a thick creamy fluid or paste. Sprinkle a pinch of salt over it, add the entire or diluted cow's milk, and the compound is ready for the foal. This system of feeding is highly spoken of by breeders of great experience.

Linseed, Bean-meal, and Milk for Foals.—Another liquid mixture used successfully in rearing foals consists of skimmed milk, linseed, and bean-meal. One formula for preparing the daily food of a foal from these substances is as follows: 12 pints sweet skimmed milk, 1 quart of linseed, which has been previously boiled for three or four hours, and 3 lb. of fine bean-meal added in a dry state. In some cases where the mares are hard-worked on the farm, the foals are weaned when only a few weeks old, and reared by the hand in some way similar to the above.

Supplementing the Mother's Milk.—In some cases the mother's milk is not sufficient to rear the foal successfully. Supplementary food should then be given,

and there should be no delay in providing the extra food, for it is desirable that the progress of the foal should be continuous. For very young foals this supplemental food should consist of diluted cow's milk, or some of the other liquid mixtures described above. The quantity given will of course depend on the supply of milk furnished by the mother and on the wants of the foal.

While it is quite true that by a liberal and judicious feeding the progress of a foal may be greatly promoted, it is equally certain that by insufficient feeding in its youth the animal may be spoiled for life. To stint or starve a foal is a most ruinous policy. Good feeding may not be able to convert a weedy foal into a first-class horse. Bad or insufficient feeding, however, may very easily transform a first-class foal into a weedy horse. The foal should be bountifully fed from the very outset and all through its career,—fed so as to maintain its health and keep it growing in size and strength. If the mother is unable to do this herself, do not delay in providing additional food to the youngster.

Health of the Foal.—During the nursing period the health of the foal must be watched carefully, so that its progress must not be interrupted by any derangement of the system that might be avoided or remedied. Young foals are liable to suffer from constipation, especially if they have not been able to suck the *first milk* from the mare's udder. The first milk is by nature provided with a moderate purgative tendency which is very beneficial to the offspring; but if the slightest symptoms of constipation appear in the foal it should at once receive a light dose of castor-oil.

Diarrhœa must also be carefully guarded against. Fresh air, exercise, protection from inclement weather, and good sound food to the mare, are the surest preventives.

Referring to this ailment in foals, Dr Fleming says: "When it appears it must be checked immediately by giving a dose of castor-oil in a little milk or gruel, and afterwards small doses of alkaline medicine—such as bicarbonate or biborate of soda, with a few drops of tincture of iron, and if there is straining or evidence of pain, a similar quantity of laudanum. Boiled rice or starch-gruel should be used as the vehicle of these medicines, as well as food in small doses at intervals. The body should be enveloped in a soft warm blanket, and the dwelling kept clean and comfortable. As the mare's milk may be the cause, the foal should be kept from her except at short intervals, and her diet ought to be changed, while tonics—as iron—and alkaline medicines, may be beneficially given to her."[1]

Housing Mares and Foals.—The mare and foal should be kept in the foaling-box for about a week or ten days. Both should then have a little exercise daily—a run for an hour or two on a pasture-field if the weather be dry and moderately warm, or merely a walk out and back again if the weather is unfavourable. Unless the weather is dry and genial, it will be prudent to keep the mare and foal under cover for three or four weeks. At the end of that time they will both be able to stand exposure to a good deal of inclement weather, if they are by degrees accustomed to the exposure, and are all the time well fed, and comfortably but not too cosily accommodated over night.

Serious losses are sometimes incurred by want of care in turning mares and foals out to pasture soon after foaling. The sudden removal from a warm foaling-box to an exposed field in cold wet weather is in itself very dangerous; while the risk is increased by the change from dry food to green succulent pasture—the result being, perhaps, serious attacks of cold, inflammation, or diarrhœa.

Great care should be exercised in the exposing of mares and foals after parturition. Let every change be introduced gradually, whether it be a change in food, from a cosy box to an open field, or from idleness to work.

It will be a good plan, if the season is favourable and sufficiently far advanced, to accustom the mare to living on a pasture-field for two or three weeks before foaling. A month or six weeks after foaling, if the weather be dry and warm and the field well sheltered, the mare and foal may be left out over night. This is the best plan for southern counties; but

[1] *Prac. Horse-Keeper*, 163.

in the north, where the spring nights are cold, it is thought advisable to take mares and foals under cover over night until well into summer.

Working Nurse-mares.—Draught mares are often returned to work two or three weeks after foaling. If circumstances permit, it would be better to delay till the beginning of the fifth week—better for the mare and the foal too. In any case, the work for a time should be light, and for several weeks the mare should not be kept longer from the foal than two or three hours on end. With good feeding the mare will be able for two yokings, of three hours' duration each, at light work, in six or eight weeks after foaling. As long as the foal is depending mainly upon the mare for its sustenance, it will be better, in a pressure of work, to take three yokings of three hours each daily from the mare, with intervals of not less than an hour, than to keep her longer in work at one time. Two short yokings daily, however, are as much as any nursing-mare should have to accomplish.

Some recommend that the foal should accompany the mare to the work, and be allowed to suck her at frequent intervals. This plan has its advantages and its disadvantages. It no doubt familiarises the foal with the society of men and of other horses, and prevents the evils that sometimes occur to both mare and foal from long fasts. But it may be dangerous to the foal to have it moving about amongst other horses, and where it may be liable to injure itself by running against field implements; while it may also sustain harm by exposure to sudden storms or chills.

It is upon the whole safer to keep the foal in more comfortable quarters, and bring the mare to it at intervals of from two and a half to three or three and a half hours, according to the stage in the nursing period.

It is most injudicious, dangerous indeed to both mare and foal, to keep the mare away from the foal until her udder is very much engorged and distended. Inflammation may arise in the udder, and unless it is at once checked, the life of the mare be endangered. Then it will be risky for the foal to allow it to suck the milk from the inflamed udder. If there is any reason to suspect that inflammation has begun, a portion of the milk should be drawn away by the hand and the udder bathed with cold water before the foal is admitted.

It is believed by some farmers that, when a nursing-mare gets overheated at work, and returns to her foal with a full udder, the milk, because of the overheating of the mare, is liable to injure the foal. They therefore draw away a little of the milk and bathe the udder with cold water. This idea, however, is not well founded. The mere heating of the mare will not spoil her milk so as to endanger the foal, and unless there is reason to fear that inflammation has begun in the udder, the foal may be admitted at once without any previous stripping or bathing.

But the overheating of nursing-mares at work is very reprehensible, and should never on any account take place.

Feeding Nursing-mares.—Brood-mares while nursing their young should be liberally fed. For the first few weeks, while the mare is kept in the house, the mare may be fed on sweet hay, given in small quantities, three or four times a-day, with bruised oats and bran, in one or two moderate feeds, and at least one mash daily, made perhaps of barley, oats, and bran and water, with a sprinkling of salt. The mash will be all the better for milk production, as well as more palatable to the mare, if a little treacle is dissolved in it. For a few days at the very outset, if the flow of milk is not sufficient, it will be well to give frequent drinks of oatmeal or flour gruel.

When nursing-mares are being worked they must be exceptionally well fed. Let them have plenty of sweet hay or fresh grass—the latter introduced gradually,—and a liberal allowance in three or four feeds per day of bruised oats, bran, and some such mash as has been described.

If the mare has not to be worked, and if grass is plentiful, and the flow of milk sufficient, nothing more will be required than what she picks up on the pasture—that is, when the grazing season has fully set in. When first turned out to grass it may be necessary to give a feed of bruised oats morning and evening for a week or two. In arranging the feeding, in all circumstances the condition of the

mare and the supply of milk for the foal must be carefully considered.

Weaning Foals.

In ordinary circumstances foals are not weaned until they are from four to six months old. The weaning of foals, therefore, does not properly come into spring work; yet, in some cases, the separation of mother and offspring takes place earlier, and it may, on the whole, be convenient to deal with the subject of weaning here.

The weaning-time is a critical period in the existence of a young horse. It is usually the first great trial of its life, and if not properly cared for at the time, the progress of the young animal may be seriously impaired. The separation of mare and foal should be effected gradually, so that to both the influence of the change may be as light as possible.

As already indicated, the foal will be trained to eat other food some time before weaning. As the time for weaning approaches, the intervals during which the foal is withdrawn from the mare will be lengthened, and the extra food increased. When the weaning begins in earnest, the foal should have admission to the mare twice daily, morning and evening, for a few days, taking care not to let it quite empty the udder at either time; then break off to once daily. And if the foal takes kindly to its other food this process need not be long continued.

Whether the weaning process is to be short or protracted will depend mainly upon (1) the manner in which the foal takes to and thrives upon the other food; (2) the condition of the mare's udder; and (3) the necessities of the time as to the working of the mare. If the foal is weakly, and does not seem to thrive satisfactorily upon the other food, it may be well to continue a little of its mother's milk for some time: better submit to some inconvenience in this way than spoil a good foal. Then the mare may have such an abundant flow of milk that the sudden withdrawal of the food would be undesirable for her sake. On the other hand, the pressure of work may require that the weaning shall be completed as quickly as possible. Thus, in weaning, there is need for experience and careful consideration.

When the foal is being weaned it should be kept out of sight and beyond the hearing of the mare, otherwise both will be restless, and may become injuriously excited. For a few days it may be well to keep the foal in a yard or loose-box, but if there is a safely fenced pasture-field some considerable distance from the mare, the youngster will thrive better there than in a house.

Feeding Foals at Weaning-time.—As to feeding, the foal should be well attended to at weaning-time. Feed it liberally but not to excess, taking care to keep its bowels and general health in as good order as possible. Bruised oats, bran, and beans, make a capital mash for foals; and some add boiled linseed. With moderate feeds of such food as this—giving the foal just what it will readily consume, but never gorging it—and a run on a pasture-field, a strong healthy foal will not be long in forgetting its mother. The youngster will soon be able to maintain itself mainly on pasture, but a little artificial food as well will be well bestowed; for the ultimate development and value of the horse may be much increased by liberal treatment in its youth. The object is to promote the growth of bone and muscle, and oats, beans, and bran, are well suited for this. Oats stand pre-eminent, and should bulk most largely.

Attention to the Mare at Weaning-time.—At weaning-time the feeding of the mare also needs careful attention, so that the flow of milk may be stopped. Hard work and spare feeding will diminish the secretion of milk. Let the food be dry and lessened somewhat in quantity. Even the allowance of water may be slightly restricted. Draw some milk from the udder once or twice a-day, or oftener if it becomes very full, but do not empty it at any time. If the secretion of milk is not diminishing satisfactorily, it may be well to give a light dose of physic. This is sometimes necessary with mares maintained solely for breeding, but rarely with mares kept hard at work.

In the event of a mare having to be dried soon after foaling, by the death of the foal or other cause, the flow of milk will usually be stopped by drawing away a little milk by the hand once or twice daily for a few days, and by giving the

mare some purgative medicine, a short allowance of dry food and little water, and plenty of work or other exercise.

The Mating Season.

The latter end of spring and early summer is the *mating season* for horses. Both mares and stallions are in the best form for breeding when in robust health, in good natural condition — just such condition as should be shown by hard-worked well-cared-for horses. Overfeeding should be avoided; it is as injurious as insufficient feeding.

A mare will usually come into *season* about nine or ten days after foaling, but occasionally not in less than twice that period. It is generally quite apparent when a mare desires to receive a stallion; but if there is any doubt, the point may easily be settled by *trying* the stallion with her.

It is advisable to serve the mare in the first heat of the season. As a rule, with healthy animals one service will be sufficient. About twenty days after the first service the mare should again be shown to the stallion, and if the usual symptoms of desire are not then exhibited by her, it may be assumed that she is pregnant. Still she may "come round" again in about three weeks, and the attendant should watch carefully for the symptoms. Some breeders think it desirable to have the mare served twice at one time, with an interval of ten to twenty-four hours; but this is not the rule.

Feeding and Treatment of Stallions. — The management of stallions during the service season requires considerable care and experience. He should be in full, natural, lean flesh, but on no account highly fattened. The food given to him at this time should be strength-giving rather than fattening. Nothing excels bruised oats and sweet hay, and of this food the stallion should have enough to well maintain his condition and vigour. With the evening allowance of hay some green food, such as tares or grass and clover may be mixed, but when the horse has much walking to accomplish, as is often the case with stallions on their rounds, a big stomachful of green food is undesirable. A little split beans added to the bruised oats will be beneficial to old stallions.

It is all the more necessary that careful attention be given to the feeding and general treatment of stallions during the service season, seeing that derangement of his system and physicking may impair his usefulness just when it is most required. Physic or drugs, if any, should never be resorted to except in cases of absolute necessity. We have no belief in the so-called prescriptions for stimulating the procreative powers of a stallion. If plenty of good sound food, such as has been indicated, with pure water and abundance of exercise, do not maintain the fertility of a horse, nothing else will.

Exercise for Stallions.—Exercise is very beneficial for stallions in the active season. It is customary for horses to make a circuit of the districts in which they are to serve, going the round three or four times in the season. In these cases the necessary walking affords ample exercise. When the stallion is stationed at a certain place and the mares brought to him, it is very desirable that he should have walking exercise every day.

Number of Mares to one Stallion. —The number of mares allotted to one stallion in a season varies considerably with circumstances, such as the age, condition, and value of the horse. An adult horse in robust active condition may have from 60 to 70 mares. The number often exceeds 80, but it is highly imprudent to overdo a stallion, and it may incur the risk of many *blanks* amongst his mares.

SWINE IN SPRING.

As with other varieties of farm live-stock the bringing forth of the young is the main feature of the spring work in the management of swine.

As pointed out in page 421, Divisional vol. ii., it is desirable that, as a rule, the fattening of pigs should be done during the warmer months, say between March and October. The times for farrowing will therefore be in the main regulated to suit this system.

FARROWING OF SOWS.

There is as much diversity of opinion as to the best system to adopt with a sow at the time of farrowing as there appears to be on most other points connected with the management of pigs. Some persons will advise that the sow should be left entirely to herself whilst she is farrowing, and others will just as strongly urge that the sow ought to have some one in attendance on her.

As with many other apparently contrary views relating to stock management, there is much to be said in favour of both systems; everything depending on the temperament of the sow, and the manner in which she has been previously treated.

Many of the common "anyway-bred" country sows, whose time is spent in a struggle or search for the bare necessaries of life, and whose aim is to give as wide a berth as possible to every human being lest they should meet with the punishment they have already deserved (or most likely will, at some future time, deserve) for their predatory habits, resent the presence of an attendant when they are farrowing. At such a time sows of this class are naturally in a somewhat excited condition.

On the other hand, the well-bred, carefully tended sow, whose experience of man is of an exactly opposite nature, appears to like rather than dislike the attendance of the person who is in the habit of feeding and looking after her. It would, of course, be most unwise to have a stranger to attend to the sow at such a time.

It has been the custom at Holywell Manor for a great number of years to have the pigman with the sow when she is farrowing; and of the many hundred of sows which have been kept there, only one was much trouble. In this case the cause of the sow being savage (no other word so well expresses her state) was afterwards discovered. Some workmen who were making alterations in the farm premises stupidly amused themselves by teasing the sow a short time before she was due to farrow. This appeared to render her almost mad for two days after the arrival of the little pigs. So excited was she that she would not allow the soiled litter (straw) to be removed, nor the pigman to enter the sty to feed her. The sow gradually tamed down, and within a fortnight was as quiet as usual.

Preparation for Farrowing.—It is a good plan to have the sow placed in the sty or house where it is intended that she should farrow, at least a fortnight before her time is up.

Period of Gestation.—The period of gestation with sows is as nearly as possible sixteen weeks. Some aged sows, and yelts with their first litters, will often farrow a day or two before the four months have elapsed; whilst the more robust sows will as frequently carry their pigs one hundred and fifteen or eighteen days, and in a few cases even a little longer.

Symptoms of Farrowing.—The pigman will easily foretell the arrival of the litter. The sow will be restless, her udder will become swollen and heated, and on the teats being drawn, moisture of a sticky glutinous nature, and sometimes milk, will be found at least twelve hours before the little pigs arrive on the scene; the vulva will become enlarged, and the muscles on either side of the tail will give way.

Litter for Young Pigs.—It is not advisable to allow the sow to have much long straw for bedding during the first few days after she has pigged, or the

little pigs may become entangled in it, and get lain upon by the sow. Some persons give their sows at this time long cut chaff for bedding, but the best material for the purpose is the wheat screenings or "cavings" from the riddles of the threshing-machine. This is both short and soft, and has no sharp ends such as are found in cut chaff.

Treatment of the Sow and Produce in Farrowing.—When the sow commences to farrow, the attendant should have ready a three-dozen size hamper, three-parts filled with wheat-straw, and as the little pigs come into the world they should be wiped with a cloth and put into the hamper, where they will rest contented and warm until the sow has finished farrowing—unless it be a very prolonged case. In the latter event the piglings should be taken out of the hamper and placed near the udder of the sow, when they will soon begin to forage about for that which nature almost invariably provides for them.

After the sow has suckled the pigs it will be advisable to again place them in the hamper and to give the sow a little slop composed of bran and sharps stirred with tepid water or skim-milk. The sow will then soon lie down again, when the pigs may be placed with her and the family party will generally rest comfortably until the return of feeding-time. In cold weather it is better to cover the hamper with a sack or cloth, as the little pigs are easily chilled before they have become dry.

The After-birth.—In some cases the sow is allowed to eat the placenta or after-birth. This should be carefully avoided. The placenta should be removed from the sty as soon as it is clear of the sow.

It will be found advisable to walk the sow out of the sty the day after she has farrowed. The little exercise will generally cause her to relieve the bowels and the bladder.

Assistance in Farrowing.—It is not often that the sow requires any assistance in getting rid of the pigs, but it will occasionally be necessary to give her help. Sometimes the little pig will present itself crosswise. At other times there may be a double presentation, or the fœtus be abnormally large. There is seldom any great difficulty in relieving the sow. The two great essentials are care and a plentiful supply of lard. The hand and arm of the operator should be small and well smeared with grease. If the sow appears to be slightly amiss a day or two after farrowing, 2 oz. of sulphur and ¼ oz. of nitre should be given to her in a pint of skim-milk. She will soon drink this up, and generally it will be all the medicine needed.

Pigs Biting Sow's Udder.—It will sometimes be found that when the newly born pigs are placed with the sow, they will fight for the teats to such an extent as to bite the udder of the sow, which at the time is especially sensitive. The sow will jump up in a hurry, and should no steps be taken to prevent the youngsters injuring her, she will often lie flat on her body and refuse to suckle the little pigs. This occurs more frequently when the sow carries her pigs beyond the usual period of sixteen weeks. The eight tusk-like teeth of the piglings will be found abnormally long, and generally of a dark colour at the root. Old-fashioned pigmen were wont to say that "these black-teethed pigs are never any good, and are sure to pine away and die." In this they were doubtless correct, unless the simple remedy of breaking off these offending teeth was applied. If this were not done the pigs would naturally become more hungry, and consequently more combative, whilst the sow's udder would become more sensitive and inflamed owing to the milk not being extracted. The usual result would be that the pigs would be starved to death from want of their natural food, and the sow would suffer from inflammation of the udder.

The remedy, a most simple and efficacious one, is to remove the pigs out of hearing of the sow, and to break off the teeth of the piglings with a small pair of pincers. If the pigs are then placed with the sow no further trouble will be experienced. Each pig will soon settle down to its selected teat, which it will make its headquarters for obtaining lacteal nutriment until it is weaned.

Weaning Pigs.—This should take place when the pigs are about six weeks old, if in summer, and about eight weeks old in the colder months. The

weaning should be done gradually, by extending the time during the last three or four days, of keeping the sow from the pigs.

Housing Brood-sows.—Fig. 333 represents an arrangement of four sties or compartments for brood-sows, all under one roof, and communicating with a

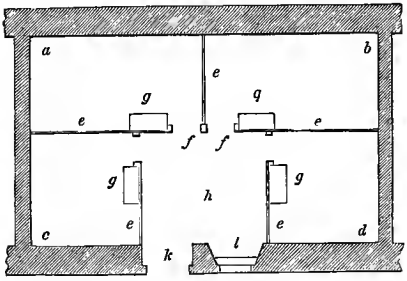


Fig. 333.—*Sties for brood-sows under one roof.*
a b Two sties, 7½ by 12 feet.
c d Two sties, 7½ by 8 feet.
e e e e Wooden partitions.
f f Four doors of sties.
g g g g A feeding-trough in each sty.
h Area from which to overlook the sties and to fill the troughs.
k Outer door of sties.
l Window for the sties.

compartment in which the attendant may provide a bed for himself.

Drains proceed from all the sties to the nearest liquid-manure drain; and the apartment is rendered comfortable by having the ceiling and walls plastered, a ventilator placed on the roof in connection with the ceiling, and the floor of brick. When two sows only are kept, the other two sties may be occupied by the weaned pigs.

Prolificacy in Swine.—In the different varieties, and even in the different strains or families of each breed of pigs, there is a marked difference in the prolific powers. This is most noticeable in those strains which have been bred for a number of years for showyard points alone, without due regard to those more useful and general-purpose qualities which are the only really valuable ones for the pig-breeder to study and cultivate. We would not for one moment wish to be understood as expressing the opinion that prolificacy, utility, and ability to win prizes are not to be found combined in several families or tribes of the different kinds of pigs. There are, indeed, numerous instances of such a happy blending, but it is undeniable that the rule is "the other way about."

Sows are capable of breeding—that is, of conceiving—when about seven months old; but it is imprudent to begin at such an early age. About the tenth month is soon enough to mate a sow with the boar.

A good breeding-sow will produce and nurse two litters in a year.

What is said in Divisional vol. ii. pp. 421-425, as to the feeding and management of pigs, should be consulted at this time.

POULTRY IN SPRING.

HATCHING.

Spring is the busy and happy season of the feathered inhabitants of the farm.

Laying Season.—As soon as the grass begins to grow in spring, so early will well-cared-for hens delight to wander into sheltered portions of pasture, in the sunshine, in the warm side of a fence, pluck the tender blades of grass, and pick up the insects which the genial air may have warmed into life and activity. With such morsels of spring food, and in agreeable temperature, their combs redden, and their feathers assume a glossy hue; and even by February they will chant—which pleasant sound is a sure harbinger of the laying season.

Selecting Sitting Hens.—By March, a disposition to sit will be evinced by early-laying hens—but every hen should not be allowed to sit; nor can any hen sit at her own discretion, where the practice is, as should be, to gather the eggs every day as they are laid.

It is expedient, then, to select the hens to bring out chickens. Those selected should have quiet dispositions, not easily affrightened, nor disposed to wander afar; should be large and full-

feathered, to cover their eggs well, and brood their young amply. Those which have proved themselves good sitters and brooders, careful and solicitous of their broods, should be chosen in preference to birds which do not exhibit these characteristics. But it is proper to make some young hens every season sit for the first time.

Selecting Eggs for Hatching.—The eggs to be set should be carefully selected. Every one proposed to be hatched should have the date of its being laid written upon it. Those of a particular hen desired to be hatched should be kept by themselves, well preserved, and set after her laying-time is finished.

In selecting eggs for hatching, they should be quite *fresh*—laid within a few days—large, of truly ovoidal shape, single, not seeming double-yolked; neither too thin nor too thick, but smooth in the shell. Their substance should almost entirely fill the shell, and be uniform and translucent when looked through at a light, which is the best test for their examination.

Sex of Eggs.—It has been said that the *position* of the cell that contains the air in an egg determines the sex of the chick—if the cell occupies the exact apex of the end, which is always the large end, the chick will be a male; and if on one side of the apex, it will be a female. But this cannot be accepted as being reliable, nor can any of the other numerous supposed methods for predetermining the sex of eggs.

Hens are required to lay eggs for the dealers of eggs, and young cocks are required for the dealers of fowls, and for converting into capons. Both businesses are carried on by different persons, and hence the utility of determining the sex of eggs. M. Génin says, that as the female skeleton of a fowl contains smooth bone, and that of the male rough, so the male egg is wrinkled at the small end, and the female is smooth at both ends. This is the result after three years' experience.

But all the indulged notions as to determining the sex of eggs, and regulating sex in breeding, have, in the case of poultry as of other animals, been proved over and over again to be fallacious. We take it that this is a law wisely kept beyond the knowledge and control of man.

The matter of sex of the egg is of no importance on a farm, as good chickens of both sexes are valuable as an article of food.

Number of Eggs in a Setting.—Either eleven or thirteen eggs are placed under a hen; eleven are more likely to be entirely hatched than thirteen, as few hens can cover thirteen large eggs sufficiently. The custom prevails even at the present day, of setting an *odd* number of eggs under a hen. This may have arisen from the idea that, allowing one egg to be a nest-egg, an *even* number of *couples* of chickens will be obtained in the hatching; and hence it is a good hatching if ten chickens are brought out from a setting of eleven eggs, or twelve from thirteen eggs.

Brood-nest.—A brood-nest for the sitting hen may consist of a circular hassock of soft straw-ropes, for a foundation on the ground, or in a box or basket. The object of this foundation is to raise the nest sufficiently above the ground to keep it dry, and to give it such a hollow as none of the eggs shall roll out by any mischance. A box or basket is a convenient receptacle for a nest, but in using either, it will be requisite to stuff the corners firmly with straw, that neither the eggs nor the young chicks may fall into them. The nest itself should be of soft short oat-straw. It should be made as large as to afford the hen ample room, not only for her body, but her tail. If the tail is bent awry while sitting, the hen will feel uncomfortable. Nests are commonly made too small. The hollow occupied by the body of the bird should not be larger than she can fill; but the sides and base of the nest should spread out to give room around the hen, and elevation above the floor.

Hatching Compartment.—Places may be chosen for the sitting hens in the regular hen-house. Hatching-places should be made to contain one hen at a time, but partitioned to separate the hens completely, as hens are jealous of each other when sitting, and will sometimes endeavour to take possession of the nest and eggs of others, or drive them away from their eggs. Other places may be selected for sitting in—

an outhouse, a loft, a spare room in the farmhouse, or even the back-kitchen, when warmth is required for early broods. Where a large number of hens are set, it is especially desirable to set apart a room, loft, or house for their accommodation. In that case, they should be set in hatching-boxes, 21 inches high, and 15 inches square, solid (except for ventilation holes) on top and sides, the front forming a door, and no bottom. The nest should be made in this on fine earth, and the hens let out for feeding once a-day.

Training Hens to Sit.—Should the hen selected for sitting have been accustomed to lay in the hen-house or elsewhere, she would feel annoyed on being transferred to new quarters; she will have to be coaxed to it, and even after all may prove obstreperous, though exhibiting strong symptoms of clucking, in which case she must be dismissed and another chosen, rather than run the risk of spoiling the entire hatching by her caprice.

Having got a quiet subject, a couple or so of old eggs should first be put into the nest, upon which she should be induced, by meat and water beside her, to sit for two or three days, to warm the nest thoroughly before the eggs she is to hatch are placed under her. After she shows a disposition to sit, and the nest warm, the old nest-eggs are taken away, and the selected eggs are put in the nest — eleven being enough — and the hen allowed to go upon them in her own way, and to manage the eggs as she pleases, which she will do with her bill and body and feet, spreading herself out fully to cover all the eggs.

Time for Setting.—The time chosen for setting the hen should be towards the evening, when the natural desire for roosting and rest arrives, and by next morning she has taken to the nest contentedly. It is usual to set a hen at any time of the day, even in broad daylight, when she is almost certain to come off and desire to wander; and to curb the disposition, a tub is placed over her to keep her in the dark. The consequent fright not only prevents her attending to the eggs, but some may be broken in her attempts to get out of confinement.

In the desire to keep the creature in the dark, it might suggest itself to any considerate person, one should suppose, that darkness is more easily found at night, and that natural darkness is better than artificial.

Feeding Sitting Hens.—While sitting upon her nest, the hen should be looked at regularly every day, and supplied with fresh food, corn, and clean water. She will not consume much food during the time of incubation, which is three weeks. Every two or three days the dung, feathers, &c., about the nest and on the floor should be swept and carried away, and the place kept clean and dry.

Testing Fertility of Eggs. — It is advisable to test the eggs when they have been sat on for a week, as in this way infertile eggs can be removed, and the work of hens economised. Many breeders set two or three hens at the same time, and if there are several eggs infertile they give all the fertile eggs to one or two hens, and place fresh eggs under those thus liberated.

The method of testing is to take the eggs into a dark place and hold them in the left hand between the forefinger and thumb, midway betwixt a candle and the eye, shading the light with the right hand also. Or an egg-tester may be used. Fertile eggs will be dark and quite opaque, whilst those which are infertile will be perfectly clear.

During very dry weather the ground under and around the nest should be moistened by a moderate quantity of warm water every other day, but the eggs must not be damped.

Chicks Appearing.—In three weeks a commotion among the eggs may be expected; and should the hen have proved a close sitter, and the weather mild, it is not unlikely that the heads of two or three chicks will be seen peeping out below her feathers before that period. The hen should not be disturbed during the time the chickens are leaving the eggs, or until they are all fairly out and dry. Any attempt to chip an egg, if not carefully done, generally kills the chick.

Feeding Chicks and Hens. — For the first twenty-four hours, or until the yolk is absorbed and digested, being the first food of the chicks, they should receive neither food nor water. After that

give water. Food is then set down to them on a flat plate, the food consisting of crumbled bread and oatmeal, or some of the well-known prepared foods, with a flat dish or small fountain of clean water. The hen's food consists of corn, or soft food, boiled potatoes, and water.

The chickens should be visited every three hours, and a variety of fresh food presented, so as to induce them to eat it the more frequently and heartily—such as picks of hard oatmeal porridge, crumbled boiled potatoes, rice, groats, or some of the well-known prepared foods,— taking care to have the food fresh and the water clean, however small the quantity that may be consumed.

Care of the Young Brood.—The hassock, or box, or basket, should now be removed, and the true nest set upon the floor, with a slope of straw from it, that the chickens may walk up to the nest to be brooded at night.

In the course of twenty-four hours, after all the chickens are on foot, the hen will express a desire to go out, which she should be indulged in if the weather is dry, and especially when the sun is out; but if it rain she had better be kept within doors, unless a convenient shed is near, in which she may remain with her brood for a short time.

Visited every three hours during the day, and supplied with a change of food and water until the feathers of the tails and wings begin to sprout, chickens may be considered out of danger, and become less of a charge.

It is not always expedient to set a number of hens at one time, but in succession every three weeks or a month; for a few chickens, ready for the table in succession, are of greater value than a large number of the same age.

Chickens should receive food four times a-day, consisting of barley and oatmeal, made crumbly and moist with hot water, or boiled potatoes, as long as they last, and the other foods already named.

Open-air Laying and Hatching.—As the season advances into summer, hens, as they become fat by picking up food in the fields, have a predilection to select places there for nests to lay eggs, and bring out chickens. It must be owned this is a most natural predilection, but no dependence can be placed in it for a regular supply of young fowls. The weather may not suit hens sitting in the open air; and hens have not the disposition to sit in the most desirable periods of the year — early and late. It is impossible to obtain a regular supply of eggs or chickens, unless provision is made for collecting the eggs and hatching the chickens in a systematic manner.

Chickens go six to eight weeks with their mother. A good hen that has brought out an early brood will become so fat while rearing them, that she will soon begin again to drop eggs, and of course again become a clucker, and may then be employed to bring out a late brood.

Hatching and Rearing Turkeys.

The hatching and rearing of turkeys are usually regarded as difficult matters. Many, however, maintain that turkeys are almost as easily reared as chickens.

When a turkey-hen is seen disposed to lay, a nest should be made for her in her hatching-house. It consists of the same materials as the hen's nest, but of larger size to suit the bird. A box or basket is an excellent thing, with the corners filled up. When once the turkey-hen lays an egg, and a nest-egg is placed in the nest, she will use it regularly every time she requires it, which will be once in about thirty hours. As the eggs are laid, they should be removed, and placed gently in a basket in the house, in a *dry* place, and turned with caution every day.

When she has done laying, which may not be till she has laid twelve or thirteen or even fifteen eggs, she will be disposed to sit, when the eggs should be placed under her, towards evening, to the number of eleven or thirteen, the eleven being the most certain of success, as a turkey cannot cover more of her own eggs than a hen can of hers; and a brood of ten poults is an excellent hatching.

A turkey need not be confined within the apartment she occupies, as she is not disposed to wander, nor is she jealous, like a hen, of another one sitting in the same apartment with her. A turkey sits four weeks, and is proverbially a close sitter.

During the incubation, corn and water should be supplied to her fresh and clean daily, and the dung and feathers removed from the nest every two or three days.

Care of Turkey-poults.—When the poults are expected, the turkey should be frequently looked at, but not disturbed, until all the poults are fairly hatched. All turkey-poults require at first is a drink of water, and they should be immediately returned to the warm nest, where the mother will receive them with characteristic fondness.

But before leaving the turkey for that night, the box or basket in which the nest is formed should be taken away, and the nest formed with a sloping face towards the floor, to enable the young poults to gain it.

For twenty-four hours the poults will eat nothing, though the turkey herself should be provided with corn, boiled oatmeal, or boiled potatoes, and water.

Food for Turkey-poults.—Next morning the young creatures will be quite astir, and ready to eat food, which should now be given them. It should consist *solely of hard-boiled eggs, yolks and white shredded down very small*, and put on a flat plate or small board.

In one respect turkey-poults apparently differ in their nature from chickens, inasmuch as they evince a tendency to purge for the first two weeks of their existence; and when purging overtakes them, it is difficult of cure, and generally proves fatal. The prevalence of this complaint among turkey-poults, it is believed, arises from the laxative condition of the food they then receive. Hard-boiled eggs being astringent and nourishing, no tendency to purging is observed with them. On the contrary, the little things are as lively and healthy as ordinary chickens, and, after their wing and tail feathers have sprouted, can bear inclement weather.

For the sake of experiment, firm oatmeal porridge was given instead of hard-boiled eggs, and in a few days two poults took the flux and died, the rest having been saved by a return to the egg. With egg for two weeks not a single death occurred among two hatchings every year for upwards of fifteen years; and this surely is sufficient experience to justify the recommendation of any practice.

Let the poults be visited every three or four hours, and supplied with hard-boiled egg and clean water. Let this food be removed after the poults are served, otherwise the turkey will devour it; for she is a keen feeder, and not so disinterested a bird in regard to food as a hen.

Let them remain two nights and one day in the house, and afterwards let them go into the open air and enjoy the sun and warmth, of which, it is hoped, there will be plenty by May. In wet weather they should be confined to the house, or go into a shed. When the birds become strong and active in the course of a few days, let the turkey be placed in a coop on the green to curb her wandering propensity, until the poults can follow her, which they will be able to do after they have been supported on hard-boiled eggs for two weeks—for three all the better. The hard-boiled eggs should be put upon a plate on the green beyond the reach of the coop, and where the poults can help themselves; whilst the food of the turkey is placed within reach of the coop.

After the feathers in the tails and wings of the poults have fairly sprouted, the egg may be *gradually* withdrawn, and hard-boiled picks of porridge, with a little sweet-milk in the dish, to facilitate the swallowing of the porridge, should be given them at least four or five times a-day at stated hours—which wholesome food will support them until the mother can provide insects and other natural food as a variety. They will now thrive apace, and grow fast as the weather becomes warm. Excellent food, specially prepared for rearing turkeys, is largely advertised.

Should the grass be damp, let the coop be placed on the gravelled walk or some other dry spot, as dampness is injurious to all young birds of the gallinaceous tribe.

After the egg is withdrawn, the poults are fond of shredded dandelion, cress and mustard leaves, and, when at liberty, pick the tender leaves of nettles with avidity. The predilections for ants and nettles show that turkeys enjoy stimulating condiments with their food. In eight or ten weeks they are well feathered. They eat rice, pot-barley, fresh curds, acorns, beech-masts, sunflower-seed.

Turkeys as Layers.—Turkeys are sometimes extraordinary layers. One season a hen-turkey, after bringing up eleven poults till they were eight weeks old, made a nest in the middle of a large bush of nettles at the edge of a young plantation, which she visited by contriving to slip away unnoticed from her brood to lay an egg *every day*. The nest was soon discovered, the egg taken away as it was laid, and a nest-egg left; and she continued to visit the nest *daily* till she had laid the extraordinary number of ninety eggs.

The consequence of this oviparous fecundity was, that she did not moult till the depth of winter, and the moulting was so very bare that she had to be confined to a warm house; and whether the misfortune which befell her before spring was owing to the late moulting, acting on an exhausted constitution, superinduced by the inordinate production of eggs, we do not know, but inflammation seized one of her eyes, and deprived her of sight. By spring she recovered from the moulting, had a new plumage, the blind eye healed, but she never recovered her condition on the best of food, and died a short time after.

Turkey-hens as Mothers.—Turkey-hens are most watchful protectors of their young, and are particularly wary of birds of prey, which, whenever observed, even at the greatest height in the air, they will utter a peculiar cry, which the poults understand, and will hide themselves instantly amongst long grass and other plants within reach.

Another peculiarity affects the turkey-hen: one impregnation from the cock fecundates all the eggs of the ovarium; and on account of this property, it is not uncommon in spring, in Ireland, for people to carry about turkey-cocks and offer their services at farmsteads. It is, perhaps, this peculiar constitutional property of the turkey-cock that makes him regardless of his own progeny, and which leads the hen to shun him as long as she has charge of a brood.

The brood goes with the turkey-hen for an indefinite length of time. Roosted on a high straw-rack, a turkey-hen has been seen to spread her wings over one of her young on each side of her, when they were nearly equal to herself in size.

Hatching Geese.

Geese make early preparation for incubation. They, however, seldom lay eggs in Scotland till the end of February. The goose and gander cannot copulate except in water; and if the pond which they frequent be covered with ice, it should be broken to allow them to get to the water, and every egg requires a separate impregnation.

Geese as Layers.—An attentive observer knows when a goose is desirous of laying, by her sitting down amongst straw and picking up and placing one on this side and one on that side of her, as if making a nest. Whenever this, or an embrace on the water with the gander, is noticed, a nest should be made for her to lay in, in the hatching-house, in a box or basket to suit the size of the bird, to which she should have easy access by the door. It is improper to confine a goose a long time before laying her first egg; but when symptoms of laying are observed, she should, in the morning, before being let out, be examined in the lower part of the abdomen; and if the egg is felt, she should be put in her nest and confined until she lays it in the course of the day, when she is let out, the egg taken away, kept dry in a basket, and turned every day until the entire number is completed—a nest-egg being left in the nest.

Produce in Eggs.—Every second day after the first, the goose will visit the nest made for her, and lay an egg, and the number will seldom exceed twelve, though eighteen have been laid. By the time she is done laying, it will thus be about the end of March.

Considerable difference in this respect exists amongst geese. They lay on some farms earlier than on others. This may arise from the nature of the soil, as probably a dry, sharp, early soil for grass and grain promotes the functions of animals to an earlier development.

Setting a Goose.—After the goose has finished laying, she will incline to sit. She should receive her eggs towards evening, so that by the morning the nest will be so warmed as to induce her to keep possession. The number of eggs to be hatched should be eleven, which is as many as a goose can easily cover. The

goose plucks the down off her breast and furnishes a lining to her nest to increase its heat; while the down also forms a covering for the eggs when she leaves her nest for a time, thus preventing their cooling.

Feeding a Sitting Goose.—A little clean water and a few oats are put beside her while she is sitting; but she will eat very little food all the time she sits. A feed of good oats, such as is given to a horse, will serve a sitting goose for a month; yet this handful is often grudged the poor patient goose. The lightest corn is only allowed by many who consider themselves good rearers of stock. In neglecting her food, the chance is that she will forsake her nest in order to search for the necessary sustenance. At any rate, it is proper to attend to her every day while she is sitting.

Some do not allow a goose to go out while she is sitting, in case she should forsake her nest; but this is an unnecessary constraint. Let her have food and water beside her, and let her go off whenever *she pleases*, and she will return to her nest in time to maintain the heat preserved by the down. Many will not allow her to go to the water at all, alleging that when she returns wet upon the eggs they will become addled; but this is a mistake. Let her go to the pond if she wishes to wash herself, and she knows better what to do for herself than her teachers; she will not continue longer than to refresh herself. Her feathers cannot become *wet*, for it is opposed to their nature; and after the relaxation she evidently so much enjoys, she will sit the closer.

Geese are liable to become costive while sitting and eating nothing but corn. To counteract this tendency, they should now and then have boiled potatoes in a crumbled state; in fact, every fowl, while sitting, should have this useful ingredient.

The Gander.—The *gander* usually takes up with one mate, but if there are only two geese, he will pay attention to both. Regard for his mate is so strong in the gander that he will remain at the door of the hatching-house like a watch-dog, guarding her from every danger, and ready to attack all and sundry that approach her sanctuary.

Period of Incubation.—At the end of a calendar month the eggs will be hatched. During the hatching the goose should be left undisturbed, but not unobserved.

Care of the Goslings.—After the goslings are fairly out of the shell, and before they are even dry, they may be taken in a basket with straw to a dry sheltered spot in a grass-field hard by, the goose carried by the wings, the gander following uttering a soft whistling sound. Here they may remain for an hour or two, provided the sun shines, and in sunshine goslings pick up more strength in one hour than from any brooding they receive from their mother for a day. The goslings endeavour to balance themselves on their feet and pluck the grass; the goose rests beside them; and the gander proudly protects them all. Water should be placed beside them to drink.

Should the sky become overcast, and rain appear likely to fall, the goslings should be carried with the goose to the nest: for if they get their backs wetted in the first two or three days of their life, they will lose the use of their legs, and die. Should the weather be wet, a sod of good short grass should be cut and placed within their house, beside a shallow plate of water. In setting down a common plate to goslings, it should be prevented upsetting, as some will put their feet upon its edge and spill the water.

After two days' acquirement of strength, in sunny weather, the goslings may venture to a pond to swim; but the horse-pond, being frequented by so many kinds of animals, is too dangerous a place for them as yet. A piece of water in a grass-field is the best place for them.

For the first few days after goslings go about, they should be particularly observed; for should one fall upon its back on the grass, or into a wheel-rut in the ground, it cannot recover its legs, will be left by the others, and perish. After three or four days in dry sunny weather, and on good grass, they will become so strong, and grow so fast, as to be past all danger. It is surprising how rapidly a young gosling grows in the first month of its life.

Feeding Goslings.—After that time they begin to tire of grass, and go in search of other food; and this is the time

to supply them daily with good oats, if fine birds by Michaelmas are desired; any other grain will answer the purpose —rice, Indian corn, let it be but corn, though oats are their favourite food. Light corn will be better than none; and if they get corn till harvest, they will have passed their fastest-growing period, and will then be able to shift for themselves, first in the stack-yard, and afterwards on the stubbles.

The sex of the gosling may be easily ascertained after the feathers begin to sprout — the ganders being white, and strong in the leg, head, and neck; the geese grey, with a gentler aspect. Goslings go with their parents for an indefinite length of time.

Artificial Hatching and Rearing of Geese.—Geese are in general close sitters; but sometimes they forsake the remaining eggs after a few of the goslings are hatched. One instance of this sort of desertion is worthy of mention. A goose after hatching five goslings left her nest, would no longer sit on the other six eggs, and would be away with the goslings she had. She was not allowed to do that; but fearing that the deserted eggs would perish, my housekeeper brought the eggs into the house, put them in a basket amongst warm flannel and wool, heated the oven gently, placed the basket with the eggs in the oven, and continued the heat in it until the goslings were hatched one by one, excepting one which had died. They occupied some days in leaving their eggs, and longer than they would have done under the goose. They were carefully attended to, taken out to the grass in the best part of the day, kept warm in the house at night, and, when the weather was bad, a grass sod was brought to them.

The goose refused to take this part of her own brood when offered her, after they had gained sufficient strength to go about: they were brought up without her aid, and became as strong birds as the rest.

This was a remarkable instance of disregard of personal trouble; and is an encouraging example of successful perseverance in the preservation of the lives of useful animals under unfavourable and even provoking circumstances.

Hatching Ducks.

Ducks will begin to lay eggs as early as November, if early hatched young ducks are selected. It is therefore possible to obtain an early hatching of ducklings. But early ducklings are rarely desirable, as, even with the utmost care, they do not acquire much flesh, their bills and bones growing disproportionately large. They indeed never become fine birds.

It is early enough to set duck-eggs in Scotland by May, and by April in England, unless, as in the Aylesbury district, a point is made of supplying the spring market.

Hens as Foster-mothers for Ducks.—It is customary to place duck-eggs under hens, owing to the difficulty of making a duck take to a nest she has not herself made. Hens make tolerable foster-mothers to ducklings, though the task imposed upon them of a week's longer sitting is not in conformity with their nature, and their tempers are frequently sorely tried when the young fleet of ducklings launch themselves upon the water and leave them, where they cannot follow.

Ducks should bring out their own kind; and it is thought that, when a duck does choose a nest for herself, lines it with her own down, and brings out a brood, that the ducklings are better than any reared under a hen; her instinct leading them to places in search of food suitable for them upon land as upon water. Still the entire production of ducklings on a farm should not be left to the chance of ducks setting themselves on eggs, for they are proverbially careless of where they drop their eggs, so that hens must be employed to hatch a few broods of ducks. A hen can cover only eleven duck eggs with ease; a lunar month is required to bring them out; and during the hatching, the hen should be left undisturbed until all the brood comes out.

Care of Ducklings.—Ducklings should be kept from water for two or three days. The food which they receive should be soft, as oatmeal porridge, boiled potatoes, bread steeped in water or milk, barley-meal brose, and clean water to drink, in a flat dish in which they can-

not swim. With this treatment, three or four times a-day, they will thrive apace, and become soon fledged over the body, when they are fit for use; but the quill-feathers do not appear for some time after. Ducklings can be made very fleshy by feeding on boiled rice in which some greaves have been mixed.

Duck-rearing in Aylesbury.—A large number of ducks are bred and reared every year, in the Vale of Aylesbury in Buckinghamshire, for the London market. The eggs are hatched by hens, and three or four broods are put together into one division; whilst other divisions contain them in a more forward state of growth, some half-grown, others full-fledged, and all are fed alike. In this way one person may have 300 or 400 ducklings feeding about the house, perhaps some of them in some cases under the same roof with the family. A great many are housed in little space, and never allowed to go at large, but permitted to wash themselves every day in a pond made on purpose near the house.

They are fed three times a-day, on potatoes, barley-meal, bran, greaves, &c., and receive as much as they can eat; and it is stated that they eat an incredible quantity of food while thus forcing for the market. When full-feathered they are sent to London, where they find a ready sale at from 10s. to 12s. a pair. As the season advances, prices fall, till they reach 4s. a pair, when the breeding is given up for the season.

Hatching Pea-fowls.

Pea-hens, in their hatching, will not be subjected to control. The hen selects a secluded spot for her nest, in which she lays about five eggs—not unlikely in a garden, where she feels herself secure from the attentions of the cock, whom she avoids at this season with marked assiduity. She takes care that he shall not know, not only where her nest is, but where the pea-fowls are when they come out, because the cock would destroy them. A pea-hen in this country seldom brings out more than three or four birds, which she tends with great care, taking them to places where wild food, insects, can be found in greatest abundance; and besides, they are fed as young turkeys, their habits being very similar. She continues to care for her young through the greater part of the year.

Hatching Pigeons.

Pigeons, when their dovecot is favourably situated for heat, begin to lay in February, and will continue until December. They make their own nests, which are of the simplest materials and rudest construction, sticks and straw laid down indiscriminately; and the same nest will be used by the same pair season after season, even after it is much elevated by the dung of the young pigeons. On this account pigeons' nests should be cleared away at the end of every brooding season. They lay only two eggs at a time. which the hen can cover effectually by pushing them below her, with her bill, amongst the feathers.

A Plea for Poultry.

What has been said on the mode of hatching the different sorts of fowls usually reared, is suitable to every sort of farm, and may be acquired by any domestic of the farmhouse; and that it is practicable and certain, our own experience for years has proved. Great schemes are recommended in books, and large establishments, consisting of buildings and ponds and spare ground, are erected and laid out in the parks and farm-courts of country gentlemen; but let any other plan be what it may, and its erections and appliances of whatever magnitude, none will afford poultry at all times in a higher degree of perfection and health than the simple methods here described.

It may not be a cheap plan, that will supply *good* poultry at *little or no cost*—such an idea of cheapness, at least, as is entertained by farmers when they condescend to cast a thought on the poultry of their farms. Fowls cannot be reared upon the *refuse* of the products of a farm more than any other sort of stock; and when one sees that the best oats, the best turnips, and the best grass that a farm can raise, are required to rear such horses, cattle, and sheep as purchasers desire to have, one must also believe that poultry require the best food to make them as acceptable to purchasers. For the plan here recommended for an ordinary farm, it can at least be said that it requires no costly buildings, and will assuredly yield

poultry in good condition at all seasons, in return for the food and trouble bestowed upon them—and what more can a reasonable farmer desire?

Fowls in Towns.—Fowls are kept, in *towns*, in places quite unsuited to their habits. Sometimes in a small court, surrounded by high walls, and the hen-house a cellar under the street pavement—a condition the very worst for fowls. The floor of the court is generally covered with dirt, and the small vessel which is intended to contain water is as often dry as plenished with *clean* water, while the food is thrown upon the dirty court-floor. Add to these the fact that the sun never shines upon the hen-house, or only for a few minutes in the afternoon, when the fowls are about to retire to roost. Ducks are treated in even a less ceremonious manner than hens; having no water, their feathers become begrimed with dirt, and their food is given them in a state little else than dirty puddle. It is impossible fowls can thrive in such circumstances; and to purchase such at a poulterer's, they cannot be deemed wholesome food.

Sand, Dust and Water for Fowls.—One cause of suffering to hens is the want of sand or gravel and lime, to assist the triturition of food and the formation of the egg-shell. Another source of suffering to them is the want of dust to burrow in and shake amongst their feathers, in order to destroy the vermin which annoy their skin; and ducks and geese suffer as much from want of water to wash in and clean their feathers.

Facts about Eggs.—Few *eggs* are worth the trial of hatching if more than a month old; their condition, however, is greatly influenced by the season and the state of the weather. An egg retains its freshness longest in moderately cool weather; very hot weather destroys vitality in a few days; and an egg having been frozen is also useless for hatching. Failures in hatching arise from want of impregnation in the egg—from age, commonly called staleness, whereby life has become extinct—from weakness of the vital energy of the eggs, produced by age, lowness of keep, or ill-health of the parent, in which cases the chick partially develops itself, but dies before the full period of incubation. Eggs may be brought to life, but unless the process of incubation be properly executed, the birds will be weakly, ill-conditioned, and die a short time afterwards.

To prevent the yolk of weak eggs settling by its specific gravity, and adhering to the shell, it is useful to pass the hand over them, so as to change their position every twenty-four hours. The egg of a strong healthy bird, at the time of protrusion from the body, is almost completely filled with yolk and albumen. If examined a few days after, by holding it toward the light, a small cell of air will be discoverable at the larger end, which increases with the age of the egg. This contraction of its internal substance, by condensation of the more volatile parts of its contents, causes the absorption of the atmosphere through the pores of the shell. When the cell is large in any egg, it is unfit for incubation; nevertheless, in a good egg, as incubation proceeds, this cell becomes considerably enlarged, probably from evaporation by heat and the vital action going on within the shell. The cell serves an important purpose in the economy of this mysterious process, by supplying the chick with its first inspiration of air. An egg will not hatch *in vacuo*.

Phenomena of Incubation.—The progressive series of phenomena, daily observable during the process of incubation in the egg of a common fowl, are curious and instructive. In an impregnated egg, previous to the commencement of incubation, a small spot is discernible upon the yolk, composed of a membraneous sac containing fluid matter, in which the embryo of the future chick swims.

1st day.—At the expiration of twelve or fourteen hours after incubation has commenced, the matter within the embryo evidently bears a resemblance to a head; vesicles assume the shape of the vertebral bones of the back.

2d day.—In thirty-nine hours the eyes make their appearance; vessels join together indicating the navel, the brain, spinal marrow, rudiments of the wings, and principal muscles; the heart is evidently proceeding.

3d day.—At its commencement the beating of the heart is visible; some hours after, two vesicles containing blood appear, one forming the left ventricle and the other the great artery; the auricle of the heart is next seen, and pulsation is evident.

4th day.—Wings assume a defined form; the brain, the beak, the front and hind parts of the head visible.

5th day.—Liver seen; circulation of the blood evident.

6th day.—Lungs and stomach distinguishable; full gush of blood from the heart distinct.

7th day.—Intestines, veins, and upper mandible visible; brain becomes consistent.

8th day.—Beak opens; formation of flesh on the breast.

9th day.—Ribs formed; gall-bladder perceptible.

10th day.—Bill formed; first voluntary motion of the chick seen.

11th day.—Skull becomes cartilaginous; protrusion of feathers evident.

12th day.—Orbits of sight appear; ribs perfected.

13th day.—Spleen in its proper position in the abdomen.

14th day.—Lungs enclosed within the breast.

15th, 16th, 17th day.—Mature state approached; yolk of the egg still outside of the body.

18th day.—Audible sign of life outside the shell; piping of the chick heard.

19th, 20th, 21st day.—Increase of size and strength; yolk enclosed within the body; chick liberates itself by repeated efforts made by the bill, seconded by muscular exertion of the limbs.

Testing Eggs for Chicks.—On the eighteenth day the eggs may, by very simple means be tested for the presence of chicks. Place the eggs gently into a basin of water heated to about 102 degrees Fahr., and every egg containing a chick will speedily show signs of life by swinging about in the water. The eggs which lie perfectly still may be regarded as rotten, and may be thrown away so as to enable the hen to devote her attention to the fertile eggs.

Embryo of the Chick.—The embryo of the chick is not in every egg placed precisely in the same situation, but varies considerably. Generally it develops itself within the circumference of the broadest part of the egg; sometimes it is found higher, sometimes lower; and when held before a strong light, has an appearance, when a few days old, somewhat resembling the meshes of a spider's web, with the spider in the centre. As it increases in size, the bulk of the contents of the egg decrease, so that when the bird is completely matured, it has ample space to move, and to use its limbs with sufficient effect to ensure its liberation.

The *position of the chick* in the shell is such as to occupy the least space. The head, which is large and heavy in proportion to the rest of the body, is placed in front of the belly, with its beak under the right wing; the feet are gathered up like a bird trussed for the spit; yet in this singular manner, and apparently uncomfortable position, the bird is by no means cramped or confined, but performs all the necessary motions and efforts required for its liberation with the most perfect ease, and with that consummate skill which instinct renders almost infallible.

The chicken, when it breaks the shell, is heavier than the whole egg was at first.

Formation of Feathers.—In regard to the formation of feathers in the chick of a bird, Raspail has the following observations: "If we examine," he says, "the epidermis of a *sparrow*, as it comes from the egg, we shall find that we can isolate each of the small bottles, which the vesicles that form the rudiments of hairs assume the shape of, as well as the nerve of which it seems to be the terminal development. It might almost be supposed that the object viewed was the eye of a *mollusca*, with its long optic nerve. The summit of this vesicle is open, even at its early period, to afford a passage for a cylindrical bundle of small fibres, which are also cylindrical, and which are nothing else than the barbs, as yet single, of the feather. If, afterwards, we examine a feather at a more advanced period, we may, by a little address, satisfy ourselves that its

tube is formed and grows by means of spathæ one within another, of which the external ones project over the inner ones, so that the tube seems as if divided by so many diaphragms. The interstices of these diaphragms are filled with a fatty liquid, which condenses in them gradually as the summits of the spathæ approximate and adhere to each other."[1]

Artificial Hatching.— The ancient Egyptian system of hatching eggs in ovens has been modified and adapted to practical wants in this country in an admirable manner. By artificial incubators, eggs may now be hatched successfully in unlimited numbers without the aid of sitting hens. For a long time artificial incubators were mere toys—expensive luxuries for the rich. But many machines are now in use which are simple, most effective, and comparatively inexpensive. In these there is to be found effective regulation of the temperature, maintaining it at the natural heat of a hen, provision of moisture, and a supply of fresh air, all of which are essential to successful hatching. Where large numbers of chickens are bred, an incubator will be found of the greatest service, both for continuous hatching and when hens desert their nests.

Caponing.— *Capons* of the common fowl are formed both of the cock and hen chickens, when they are fit to leave the hen, at about six weeks old. Chickens are transmuted into capons by destroying the testicles of the male and the ovaries of the females; the latter being known by the French name *poularde*.

The testicles are attached by a membrane to what is called the *backbone* of the carved fowl. They are destroyed by laying the bird on its near side, keeping it down, removing a few feathers, and making an incision through the skin of the abdomen, and, on introducing the fore-finger through the incision, first the one and then the other testicle is obliterated by pressure of the finger. In the case of the hen, the ovary is nipped off by the thumb-nail, or cut off by a knife. The incision is stitched up with thread, and little danger is apprehended of the result. To facilitate the process, there are instruments sold by various makers.

The *effect of castration* is enlargement of the body of the fowl, and increased delicacy of its flesh; but its flavour is in no way improved. Time was when capons were more plentiful at the table than chickens, so that even kain-rent was paid in them. But the conversion of fowls into capons is now almost abandoned in Scotland, as an unnecessary and troublesome operation—and will not probably be resumed as long as a well-fed delicate chicken can be procured with little trouble,—although the London market is always well supplied with them.

Turkey-poults are converted into *poulardes* by the same operation, which produces similar effects upon their size and condition.

Temperature for Incubation.—We are not aware that any experiments have been made to ascertain the exact temperature which is maintained in a nest containing eggs under incubation. Boswell simply says, "To have eggs productive, they must be subjected to an equable temperature of about 96° Fahr. during at least three weeks."[2] This is about blood-heat. F. Malézieu states that the Egyptians in their hatching apparatus maintain a heat of from 63° to 72°; and that Gerard, in his hatching establishment at Paris, is content with a heat of 66° to 70°.[3] Judging from the heat of the body of a fowl, and the long and constant sitting, we should expect the temperature to be higher than the blood-heat of man, in a nest devoted to hatching.

Now, it is generally accepted that 104° is the temperature for incubation; but it has frequently been proved in incubators that hatching will take place from 102° (or even 101°) to 106°. They will not hatch with the heat at 100°, or below 95°.

Poultry Dung.

Anderson has analysed the dung of domestic poultry, obtained in as fresh a state and as free of foreign matters as was possible. The specimens were sup-

[1] Raspail's *Org. Chem.*, 283.

[2] Boswell, *Poul. Yard*, 85.

[3] Malézieu, *Coqs. Domes.*, 49, 58.

plied by John Gibson, Woolmet, and the results were:—

Pigeon Dung.

Water	58.32
Organic matter	28.25
Phosphates	2.69
Sulphate of lime	1.75
Alkaline salts	1.99
Sand	7.00
	100.00
Ammonia	1.75
Phosphoric acid in the alkaline salts equal to 0.20 phosphate of lime,	0.10

Hen Dung.

Water	60.88
Organic matter and ammoniacal salts	19.22
Phosphates	4.47
Carbonate of lime	7.65
Alkaline salts	1.09
Sand	6.69
	100.00
Ammonia	0.74
Phosphoric acid in the alkaline salts equal to 0.15 phosphate of lime	0.70

Duck Dung.

Water	46.65
Organic matter and ammoniacal salts	36.12
Phosphates	3.15
Carbonate of lime	3.01
Alkaline salts	0.32
Sand	10.75
	100.00
Ammonia	0.85
Phosphoric acid in the alkaline salts	trace.

The small proportion of ammonia deserves notice.

Goose Dung.

Water	77.08
Organic matter and ammoniacal salts	13.44
Phosphates	0.89
Alkaline salts	2.94
Sand	5.65
	100.00
Ammonia	0.67
Phosphoric acid in the alkaline salts equal to 0.26 phosphate of lime,	0.12

Three-fourths of this dung consists of water, less than one per cent of phosphates, and two-thirds per cent of ammonia, while the alkaline salts are large.

The conclusions from these analyses are, that pigeon dung has a value not exceeding three times that of farmyard manure, and that the other kinds of poultry dung scarcely, if at all, exceed it in value.[1]

PARING AND BURNING.

Paring is the removal of a thin portion of the surface of the ground, with what may be growing upon it. *Burning* is the reduction by fire to a state of powder, of what has been pared off.

Object of Paring and Burning.—The object of the process is to assist in reducing rough surface-soil into a workable condition more speedily than could be accomplished by the slower influences of tillage and cropping.

The practice was at one time pursued to a considerable extent, but has very properly lost in repute.

As to the advantages and disadvantages of paring and burning there is great diversity of opinion amongst practical farmers. For the sake of those not acquainted with the process, we may here briefly state the arguments for and against the practice.

Advantages of Paring and Burning.—The advantages which result from the operation are—

(1) The change produced in the mechanical condition of the soil, the texture being altered — opened up — especially upon stiff clays, by the admixture of the ashes which result from burning.

(2) In peaty soils, or where a large amount of rank and coarse vegetation covers the ground, a complete change is quickly effected by the process—rendering the future breaking-up of these soils by the plough a matter of easy accomplishment.

(3) Leas and old pasture are frequently infested so much by the larvæ of insects, notably wire-worm (*Elater lineatus*) and the grub of the daddy-longlegs

[1] *Trans. High. Agric. Soc.*, Jan. 1864, 170.

(*Tipula oleracea*), that the prospect of the corn crop is rendered doubtful. These, as well as the seeds of noxious weeds, &c., are destroyed by this practice.

(4) Burning is one of the quickest agents employed in agriculture for the conversion of the dormant ingredients of the soil into an active or soluble form. Heat breaks up the various compounds, separating the acids from the alkaline bases, which, forming more simple compounds, are to a greater extent soluble in water, and in consequence in a fit state to be assimilated by the roots of plants.

Disadvantages of Paring and Burning.—These advantages are obtained at the sacrifice of all the organic portion of the soil, which, being volatile, is dissipated by combustion, passing into the air in the form of gaseous bodies. It is also found that while potash is rendered more soluble by the action of heat, phosphoric acid is rendered nearly insoluble. Over-burning also frequently occurs, and this on a clay soil will convert the residue into brick-dust, a spreading of which may increase the friability of a soil, but can have no action in increasing its fertility, as it becomes insoluble matter. Then, in peaty soils, in dry weather, the former may ruin its producing power by the total destruction of the humus or vegetable matter.

Useful on Certain Soils.—From the foregoing it would be inferred that paring and burning might be carried out with advantage on stiff clays, where the loss of the small amount of organic matter which may be present is compensated by the increase of soluble inorganic matter; or on a soil which is made up largely of inert vegetable matter, such as peat; and on soils infested with larvæ, or seeds of weeds. Some calcareous soils might perhaps also be burned to advantage.

Lime Essential.—But no matter what soil is burned, the full benefit of the operation cannot be obtained unless lime is present. Lime is absolutely necessary for the liberation of potash and soda. It is good practice, therefore, to give a coating of lime where such is deficient before the work of paring and burning is commenced; while after completion the soil ought to be heavily manured with nitrogenous manure.

Paring and Burning Condemned.—Still, with due recognition of all that has been claimed for the practice, we are bound to say that we regard it as entirely out of keeping with the spirit of the age. This view of the matter is well expressed by Mr George Brown, Watten Mains, Caithness, who, writing for this edition, says: "The practice is objectionable, and is based upon wrong principles. All the advantages claimed for it may be derived by following the ordinary routine of farm practice. If a farmer has rough land let him plough it early in spring, summer, or autumn — the earlier the better — and leave it to the ordinary forces of nature until the following spring; sow it then with oats, and again plough early, taking another crop of oats. In the third year it will be ready for a turnip crop. If a little rough after sowing, give a turn of a heavy roller along the drills, and a heavy crop will be the result. This method (which is in accordance with sound practice, backed by the latest researches of science), the writer has seen pursued with success upon hundreds of acres of waste land and heath when first reclaimed."

Methods of Paring and Burning.—Having thus given expression to the prevailing views for and against paring and burning, we now append some notes as to the different methods of carrying out the process.

Fig. 334. *Common spade.*

Various implements are employed to execute paring and burning. The common No. 5 garden spade, fig. 334, with a sharp edge and its corners a little worn by work, removes rough herbage very well, and the turfs can be set up at the time by the workmen to be dried. But the labour with it entirely is expensive, and is seldom incurred.

Flauchter-spade.—A more expeditious implement is a spade of a different form, fig. 335; the face of which is angular and sharp, the blade 9 inches broad and 15 inches long; the straight side of which is turned up

square 3 inches, with a cutting-edge in front; the helve is 5 feet long and flat, provided with a broad cross-handle 2 feet long, fastened at right angles to the helve. The blade is set at an angle to permit the handle to be elevated to a man's haunches, while the blade works flat upon the ground. It is called in Scotland the *flauchter-spade*, from the Teutonic verb to flauch or take off the skin.

The mode of using this implement is this: "The workman is provided with a short leather apron faced with two boards

Fig. 335.—*Flauchter-spade at work.*

in front of the groin, the apron being buckled round the waist and round the upper part of the thighs. The blade of the instrument is laid flat on its sole, and its point is made to enter the ground by a push of the body of the workman upon the handle placed against the boards in front of his groin, and there held by both hands. The body gives successive pushes, longer or shorter, as the nature of the ground admits; and the point is made to dip deeper, keep level, or move upwards, by the direction of the hands, according to the thickness of the surface to be removed. At each push the point cuts forward under the turf, while the cutting edge severs the loosened turf from the solid surface. When the turf is 1 or 2 feet in length, according to the state of the surface, it is turned upon its back or side, on the pared surface on the left hand, by a sudden jerk of the handle. The edge of the spade is kept sharp with a scythe-stone. The thickness of the turf removed depends on the strength and skill of the workman, but it seldom exceeds 2 inches even in the softest parts of the ground, and more often 1½ inch. It takes a man one week to turn over one acre of ground, and he is paid 3s. or 4s. a-day, or 20s. an acre, for his hard work."

Paring-plough.—A more expeditious method still is to pare off the surface with a horse and plough. An English paring-plough, made by Vipan & Headly, Leicester, is represented in fig. 336.

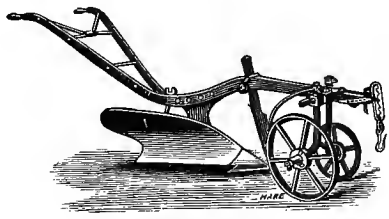


Fig. 336.—*Paring-plough.*

This plough is specially adapted for paring the tough surface off an old pasture about to be broken up, or for paring stubbles to facilitate the removal of surface weeds. It pares to a depth of from 1 to 3 inches, and with a pair of horses will cover from 1¼ to 2 acres per day.

The ordinary plough may be fitted for paring by having the feather of its share widened to from 12 to 15 inches. Fig. 337 is the share of the common plough, the breadth of whose feather is 10 inches, but by welding a wing 3 inches in breadth,

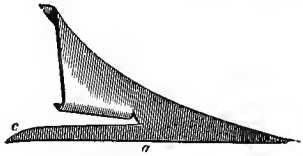


Fig. 337.—*Paring-sock.*

a Breadth of sock, 10 inches.
c Ear of feather, 15 inches in breadth from land-side.

having a sharp edge upon the outer side of the feather, the paring-face is increased to 15 inches in breadth from the land-side of the share. When the paring is finished, the wing can be cut off, and the share is again fit for ordinary use. The mould-board cannot lay over so broad a furrow-slice as 15 inches as it lays over in lea; the broad furrow-slice being partly rolled over upon itself, which is in its favour for drying.

Paring with the plough is, of course, much less expensive, as well as more expeditious, than paring with the flauchter-spade. Where the ground is even, the plough with wide share will turn over the entire surface; but in uneven and much-broken ground, where stones abound, it cannot be used, and the flauchter-spade must be employed; while the common spade is used in small deep hollows, or among thick masses of herbage. Thus all the implements may co-operate to complete what one alone could not do so well.

When the turfs are laid over by the spade, the workmen might set them up one against the other, though not so neatly as by hand. The flauchter-spade, taking up a long thin turf, cannot get quit of it without either laying it flat or setting it partly on edge. The broad continued turf laid over by the share of the plough must fall flat upon the ground, and be set up by hand to be dried. A *paring-plough*, which has been used in parts of England in the fens, pares the turf by means of two angular shares with the wings facing each other, and just crossing the centre line, one being a little before the other; and they are attached to shanks, placed in front of the mould-board, upon which the turf is raised in a manner similar to the furrow-slice in ordinary ploughing, and is set on its edge upon the pared ground, ready to be dried, as neatly as if done by hand.

Expeditious Paring.—Perhaps the most expeditious mode of procedure would be to take a couple of tines out of a common grubber and cross the land to be pared, then start an American chilled plough at the required depth. The breadth of the share and curve of the mould-board are suitable for the work, and by the previous crossing with the grubber-tines, the surface would be left in good-sized turfs for burning.

Time for the Process.—Paring may be executed any time during the winter and spring, but it is best and most easily done from February to April. It is difficult to do when the ground is dry and hard, but in boggy land it is best done in dry weather. While boggy land is very wet it cannot be done at all, the footing then being insecure, and the soil soaking with water; nor in clay land, when wet, as the surface soon becomes poached.

Drying the Sods.—The sods are set up on edge against one another in the way best to expose the largest surface to the air, to be dried in the quickest time for being burned. The long continuous turfs turned over by the ploughs require to be cut in convenient lengths with the spade before they can be set up to dry. In dry weather they are ready to be burned in about two weeks.

Process of Burning.—In burning, the fires must be begun with some combustible materials—as wood, chips, shavings; and at first they must be strictly attended to, in order to have the *first* turfs completely dried. After these have begun to burn, surround them with fresh sods, to keep the fire in a smouldering state, and not to flame or burn fiercely. A number of fires should be lighted one after the other, the field-workers carrying the turfs to supply them with fresh sods, placing them thickest on the windward side to keep down the force of the fire. This being the object, the turf, after the first dried ones, should not be too dry before the burning begins. The heaps are supplied with turfs until they attain a large size, capable of containing from ten to fifteen cart-loads of ashes, and the larger the heap the less effect has the air on the ashes.

The dried and burning turfs from one heap will supply fire to begin the burning of other heaps. To prevent the fire breaking into combustion through the night, the heaps should be well covered with fresh sods in the evening, partly to be removed in the morning. When the fire gets dull, a hole in the windy side, punched into the heap with a stake, will give it life. In a large heap there is no fear of the fire being extinguished, although there be no symptoms of activity on the outside. A heavy rain cannot put out the fire of a large heap.

To obtain good results, the burning should not be conducted in a thoughtless manner, but done to a plan previously fixed upon.

A Good Plan.—A good plan is to burn one row of heaps, then another, and to begin at that side of the field most convenient to plough the ground. Having gathered the turfs on both sides of a line of heaps, a space of ground will be cleared of turf; and as one line of heaps

is constructed and burning, let another be begun from the end where the former line finished, until all the field has been heaped and burning. The charred turfs of the previous line will be easily carried across the ground to the line to be formed.

Cooling the Heaps.—The time that may elapse before the burned heaps become cold depends on the state of the weather, but it will be considerable if the heaps are allowed to cool of themselves. The hot ashes may be spread to cool, if required soon; but should wind arise after a heap has been broken, the ashes will be scattered, or be blown off the ground altogether. Caution is requisite in opening up a heap.

The Ashes.—When thick turf has been laid over by the plough, it will afford more ashes than the ground requires at one time. To avoid a superabundance of ashes, some pare as much turf in strips as will just supply the ashes wanted. To effect the stripping, the ear of the feather of the share is turned up with a cutting-edge. But where the herbage is rough, the strips left are as difficult to reduce as ever.

The better plan is, to pare and burn all the surface, and carry off the extra ashes to another field about to bear a green crop; and as carrying away ashes implies robbery of the land which has supplied them, a substitute should be provided in farmyard or other manure.

The burning of heaps in line clears the ground for the plough, which is feered between the heaps, to ridge the land in any form desired; and before the land is ploughed the ashes are spread upon it. This is the simplest mode of applying the ashes; for if they are not spread until after the dung for turnips has been laid on, as some writers recommend, the ashes will have to be carried off the field, and then brought back when wanted.

Time to Plough in Ashes.—"There are two methods, one to spread and plough in immediately, the other to spread immediately, but to have them exposed to the atmosphere some months before turning in. Mr Wedge, on the thin sandy soil on a chalk bottom of Newmarket heath, had in one a treble experiment: part was pared and burnt in the spring, and the ashes spread and exposed till ploughing in the autumn for wheat; part pared and burnt late, the ashes left in heaps, and spread just before ploughing the wheat; the third pared and not burnt at all, by reason of bad weather. The first was by far the best, the second the next, and the third beyond all comparison inferior."[1] The superiority of the results from the first method was, no doubt, due to the ashes having in their exposure absorbed ammonia from the atmosphere.

Changes involved in Burning Soil.—The chemical and physical changes which occur in the burning of soil may be stated thus: Combustion and decay are synonymous;—the ultimate results from each are similar, but the proximate organic compounds are different. Combustion acts quickly, and dissipates organic matter in the form of carbonic acid, ammonia, and watery vapour. Decay acts more slowly, and allows these volatile substances to recombine with the alkalies and acids present in the soil, thus forming soluble salts, such as carbonate of lime, and nitrate of potash, or lime. Chief of the inorganic compounds is silicate of ammonia, which cannot be held as plant-food; but, according to Professor Tanner, in combination with this compound there are others—viz., silicate of potash and lime in certain proportions—forming double silicates. This compound is broken up by the action of heat, and the silicic acid having a greater affinity for ammonia, the potash is driven out and recombines with other free acids present. Lime, being rendered caustic by the process also, comes into contact with salts of potash, and liberates the base and combines with the acid.

Thus we learn that a constant change is taking place, the complex or insoluble compound being rendered simple or soluble, all being regulated by chemical affinity.

Apart from chemical action, burned clay, charcoal, &c., have a great power of absorption, and many maintain that the ammonia lost by burning is fully compensated by the power the burned residual matter has for absorbing this wonderful agent in plant-growth.

[1] Pott's *Brit. Far. Cy.*—art. "Par. Burn."

SUMMER.

THE WEATHER.

As spring is the restoration of life to vegetation, and the season in which the works of the field are again in activity, so summer is the season of *progress* in vegetation and in the works of the field. This advancement involves no difference of practice, only impressing into its service many minor works for the first time, in assistance to the greater. Many of these minor operations being manual, and performed in the most agreeable season of the year, they are regarded with peculiar interest and delight by the light-hearted farm-workers.

Atmospherical Complications in Summer. — The atmospherical phenomena of summer are not only varied, but of a complicated character, difficult of explanation, and apparently anomalous in occurrence. There are *dew*, which is a great deposition of water at a time when not a cloud is to be seen; a *thunderstorm*, which suddenly rages in the midst of a calm; and *hail*, which is the descent of ice and congealed snow in the hottest days of the year.

Dew. — The phenomenon of *dew* is familiar to every one residing in the country. In the hottest day of summer, the shoes become wetted on walking over a grass-field about sunset, and they may be wetted as thoroughly as in wading through water. Wells investigated the phenomena of dew more closely than any other man of his time. His experiments, as detailed in his instructive and amusing essay on that subject, appear to have been very satisfactorily conducted, and the theory which he established by these experiments has been generally embraced by philosophers.

Cause of Dew.—Briefly, the cause of dew is unreciprocated radiation—the radiation of heat from the earth, plants, and other bodies upon which dew is formed. The earth during the day both absorbs and gives out heat. The supply of heat for absorption of course ceases with the setting of the sun, but the earth and bodies upon its surface continue to radiate or emit heat during the night. Objects which are good radiators, such as grass, flowers, and foliage generally, give out heat readily, and thus when during night they emit heat without receiving any in return, their temperature falls below that of the atmosphere which surrounds them. The cold surface of these plants attracts and condenses the vapour in the adjacent air, which deposits itself in the form of dew. Hoar-frost is similarly formed, the condensed vapour taking the shape of hoar-frost when the temperature of the earth is below freezing-point, or 32° Fahrenheit.

The reason why little or no dew is formed when the sky is clouded is that the clouds, being good radiators, give back as much heat as they take away from the earth, thus maintaining an almost even balance of temperature between the earth and the surrounding air.

Beneficial Influence of Dew.—The deposition of dew is a happy provision of nature. Often when the rainfall is insufficient, the wants of vegetation are supplied by dew. This is particularly the case in tropical regions where there may be little or no rain for months, and where, owing to the rapid radiation of heat at night, and the great evaporation of moisture from the soil into the surrounding atmosphere during the day, abundant dews are deposited.

Dew is often found upon plants when bare soil and stones close at hand show no traces of it. This arises from the fact that plants have much greater radiating power than soil and stones, and thus the former fall more quickly in temperature after sunset. Wind tends to prevent the formation of dew by carrying away the particles of vapour before the adjacent colder bodies have been able to condense them.

Measuring Dew.—To measure the quantity of dew deposited each night, an instrument is used called a *drosometer*. The most simple process consists in exposing to the open air bodies whose exact weight is known, and then weighing them afresh after they are covered

with dew. According to Wells, locks of wool, divided into spherical masses of 3½ inches diameter, are to be preferred to any other thing for measuring the deposit of dew. All circumstances that favour radiation equally contribute to the formation of dew. A body that is a good radiator and a bad conductor of heat, will therefore be covered with a very abundant dew. Thus glass becomes wet sooner than the metals; organised bodies are wetted more quickly than glass, especially when they are in small fragments—because, as the heat passes with difficulty from the one to the other, that which is lost is not replaced by that which is transmitted from the interior to the surface of the body. Locks of wool are therefore well suited to these experiments, and become covered with a very abundant dew. The moister the air is, all other things being equal, the more considerable is the quantity of dew that falls in a given time.

Dalton computed the amount of dew which annually falls at five inches. In fine weather, in the evening, the vapour-plane being destroyed, and the nubific principle, as Forster observes, ceasing to act, the vapour so deposited comes down in dew. Dew, however, is not the result always of the stratus cloud, and it differs from the wet mist of the cirro-stratus of the lower atmosphere.

Heavy Dews Foretelling Rain.—In our country, nights with abundant dews may be considered as foretelling rain; for they prove that the air contains a great quantity of the vapour of water, and that it is near the point of saturation.

Thunderstorms.—Summer is the season in which electricity is most active in displaying its existence.

The electric fluid accumulates in the clouds of vapour. When two clouds, thus provided with electric matter beyond their usual state, are not far from each other, the electricity of the one always becomes *positive*, and that of the other *negative*. They thus attract and approach each other; and when they come so near that the force of the positive electricity is able to overcome the resistance of the air between the positive and negative clouds, the fluid leaves the positive and enters into the negative cloud in lightning in such quantity as to restore the equilibrium of both. The forcible passage of the fluid causes such a concussion in the air as to give rise to the noise which is heard in *thunder*.

The time taken by the electric fluid to pass from one cloud to another is inappreciable, but the velocity of sound is calculable. It has been calculated that for every 4½ seconds of time which elapse after seeing the lightning to hearing the thunder, the clouds are situate one mile from the auditor.

Lightning.—Lightning is of three kinds. First, *forked*, or zigzag, lightning; second, *sheet-lightning*; and third, *ball-lightning*. Ball-lightning is regarded as very dangerous, and unfortunately the lightning-conductor is no protection against injury from it.

Motion of Electricity.—The motion of the electric fluid is most commonly from the clouds to the earth, though numerous examples exist of its having followed an opposite direction. It is probable, however, that in most cases of electric explosion the fluid leaves both clouds, or the cloud and the earth, at one time. However this may be, the stroke always goes in the most direct line, even through substances of the least conducting power. Animals are frequently struck, because their fluids easily conduct the fluid; while the shock given to the body seems to be through the nervous system.

Lightning-conductors.—Hence lightning-conductors have been recommended not only to draw off the fluid quietly from the atmosphere into the earth, which they certainly do when attached to houses, but also with the view of lessening the number and virulency of thunderstorms, which it is doubtful that any number of conductors would effect.

Thunder has never been heard at a greater distance than 14 miles from the flash of lightning. The report of cannon has been heard at a much greater distance. Indeed it is stated that the cannonading at the battle of Waterloo was heard at the town of Creil in the north of France, a distance of 115 miles from the field of battle.

Utility of Thunderstorms.—Thunderstorms are of great use in the economy of the atmosphere. The surplus electri-

city is disposed of to the earth, the surplus vapour is condensed and sent down to the earth in rain, the air is prevented from becoming stagnant, the extraneous matters floating in the air are brought down to the earth, whether these be in a solid or gaseous state.

Hail in Summer.—The fall of ice from the atmosphere in hot weather is a phenomenon not easily solved. That both snow and ice are required in the formation of *hail* there cannot be a doubt.

Hail generally falls in the hottest hours of the day in Spain, Italy, and France. It falls in Europe generally in the day, and seldom in the night.

Sleet.—Small hailstones mixed with snow and rain are termed sleet. The largest are sometimes surrounded with a slight film of ice. Sleet falls in winter and spring during gusty weather, and rarely accompanies storms, but always falls during gales. When the weather is variable, such gusts of cold wind seem a necessary condition for the formation of sleet.

Summer Rain.—The character of rain in summer is refreshing. Even in a rainy season, though we may feel displeased at being kept within doors on a summer day, we feel assured that it will in a great measure be absorbed by the varied mass of vegetation which is in constant activity during this season. Since the experiments of Hales proved that a sunflower plant, 3½ feet high, and an ordinary-sized cabbage, on the average perspire 22 ounces of water, and consequently absorb as much every twenty-four hours,[1] one may judge of the immense quantity of water required daily to supply the wants of vegetation. And when it is known that evaporation, besides, carries an incredible amount of vapour direct from the surface of the ground into the atmosphere, one may wonder whence all the requisite moisture can be derived, rather than imagine that too much has been provided.

The boundary-line of the province of summer rains in Europe proceeds W. from the Carpathian mountains to the N. of the Alps, through the middle of France, the W. of Holland, and by the N. part of the Gulf of Bothnia, through the White Sea to the Arctic Ocean,[2] and it includes all that large portion of Europe to the E. of it.

Rain without Clouds.—Every one may have observed rain to fall without the appearance of a cloud. When the equilibrium of the higher regions is violently disturbed, especially when any cold N. winds come into collision with those from the S., it may happen that rain falls from a serene sky. Large drops are seen to moisten the earth, and yet at the zenith the sky is blue. The vapours condense into water, without passing through the intermediate state of vesicular vapours as clouds. Humboldt gives several examples of the kind, and Käemtz remarks from his own observations that the fact is not very rare, having observed it two or three times annually.

Summer Wind.—The character of the winds in summer in this country is gentle and refreshing. This is the season for the land and sea breezes. In fine weather, on the sea-coasts, no movement is perceived in the air until eight or nine o'clock in the morning, when a breeze from the sea gradually rises, and increases in strength till three o'clock in the afternoon, when it decreases, and gives place, after a short period of calm, to a breeze from the land towards the sea, which rises soon after sunset, and attains its maximum of velocity and extent at the moment of sunrise. The direction of these two breezes is perpendicular to the coast-line; but if another breeze arise at the same time, both are modified in various ways. On the E. coast of this island, when the wind blows from the E. the sea-breeze is strong, and the land-breeze weak; and on the W. coast, the land-breeze is stronger than the sea-breeze. These effects will be the contrary with a W. wind. In a wind from the N. or S., both the land and sea breezes will be changed in their direction respectively to the N.E. and S.W. The sea-breeze is very weak in gulfs, and the land-breeze is as weak on promontories.

A day wind betwixt the mountains and plains exists in the same manner as the land and sea breezes, though to a less degree.

The alternation of all these winds is

[1] Hales's *Stat. Ess.*, i. 12, 15.

[2] Johnston's *Phys. Atl.*—"Meteo.," Map iv.

explained by the unequal heating of the land and of the sea, and of that of the mountains and the plain; and as continents are hotter in summer and colder in winter than the contiguous sea, the sea-breeze ought to predominate in summer, and the land-breeze in winter.

In summer, when the wind is variable, rain is indicated, and also when the wind blows along the surface of the ground and raises the dust upwards. When currents of air are seen to move in different directions, the upper one will ultimately prevail. When it is uncertain whether there be any breeze, the lifting up of a wetted finger will instantly feel the current, and indicate the quarter from whence it comes.

In summer, especially in July, the wind blows chiefly from the W. — the predominance of W. winds over E. at this season attaining its maximum; and at the same time the N. winds become more common; whence it follows that the mean direction of the wind in this season is N. of the annual mean.

When the wind blows strongly from any quarter, even from the S.W., which is the warmest wind in summer, for two or three days in succession, the temperature of the air is diminished, sometimes as much as 20°, and seldom less than 10°. When small whirlwinds are seen raising the dust upon the roads or fields, it is a sign of dry weather.

Evaporation.—In proportion as the sun rises above the horizon, evaporation increases, and the air receives a larger quantity of vapour. The fact of the rising of vapour from the ground may be distinctly observed in summer by the flickering of distant objects seen through it; and as the air, by its gravity, opposes an obstacle to the rise of vapour, the air becomes further and further removed from the point of saturation, its humidity becoming more and more feeble. The rate increases until mid-day, when the maximum occurs, and in different months it occurs sooner or later. The absolute quantity of vapour diminishes, until the time of the highest temperature of the day, without however attaining a minimum so low as that of the morning. As the temperature rises during all this space of time, it follows that the air is farther and farther from the point of saturation: after having attained its minimum, the quantity of vapour again increases very regularly until next morning, while the air becomes relatively more and more moist. Vapour being the result of the action of heat on water, it is evident that its quantity must vary in different seasons. The quantity of vapour attains its maximum, 11.626 per cent, in July, the month in which the air is driest. Evaporation is nearly twice as active in summer as in spring.[1]

Light.—*Light* is a most important element in nature for the promotion of vegetation in summer. Its properties are most evidently manifested in this season, and have been shortly and forcibly enumerated by Lindley. "It is to the action of leaves," he observes—"to the decomposition of their carbonic acid and of their water; to the separation of the aqueous particles of the sap from the solid parts that were dissolved in it; to the deposition thus effected of various earthy and other substances, either introduced into plants, as silex and metallic salts, or formed there, as vegetable alkaloids; to the extrication of nitrogen, and probably to other causes as yet unknown,—that the formation of the peculiar secretions of plants, of whatever kind, is owing. And this is brought about principally, if not exclusively, by the agency of *light*. Their green colour becomes intense, in proportion to their exposure to light within certain limits, and feeble, in proportion to their removal from it; till, in total and continued darkness, they are entirely destitute of green secretion, and become blanched and etiolated. The same result attends all their other secretions; timber, gum, sugar, acids, starch, oil, resins, odours, flavours, and all the numberless narcotic, acrid, aromatic, pungent, astringent, and other principles derived from the vegetable kingdom, are equally influenced, as to quantity and quality, by the amount of light to which the plants producing them have been exposed."[2]

The advantage that summer possesses over the other seasons as regards light, is seen in its comparative duration in

[1] Käemtz's *Meteo.*, 92.
[2] Lindley's *Theo. Horti.*, 52.

the respective months. Summer indeed enjoys more than double the light of winter, a half more than spring, and a third more than autumn. Thus—

In Winter,

November has 8 hours 10 minutes of light a-day.
December " 7 " 8 " "
January " 7 " 44 " "
Making a mean of 7 " 41 " "

In Spring,

February has 9 hours 30 minutes of light a-day.
March " 11 " 49 " "
April " 14 " 9 " "
Making a mean of 11 " 49 " "

In Summer,

May has 16 hours 11 minutes of light a-day.
June " 17 " 16 " "
July " 16 " 45 " "
Making a mean of 16 " 44 " "

In Autumn,

August has 14 hours 34 minutes of light a-day.
September " 12 " 23 " "
October " 10 " 17 " "
Making a mean of 12 " 25 " "

Besides its existence for a greater number of hours each day, light is of greater intensity in summer than in the other seasons, because it is then transmitted through the atmosphere at a higher angle. The light of the sun or of the moon, in its passage across the meridian, is dazzling to the eye, whilst we can gaze without difficulty at either body when near the horizon, because the rays cannot so easily penetrate through the thick stratum of atmosphere and of vapour they have there to traverse, in which, moreover, many of them are absorbed.

Heat of the Sun.—As heat always accompanies light with the solar rays, its intensity increases with the light. It would appear that a very large proportion of the heat of the solar ray is absorbed in passing through the atmosphere, and that the proportion is increased as the sun approaches the horizon.

Summer Weather Prognostics.—In summer, weather prognostics are numerous. Falling-stars generally indicate the approach of a thunderstorm. Fire-balls are not uncommon on warm summer nights. The *barometer* remains pretty stationary in summer, and comparatively high, any remarkable oscillation being a sudden fall before a violent wind from the S.W. It was an observation of Dalton, that in summer, after a long continuance of fair weather, with the barometer high, it generally falls gradually, and for one, two, or more days, before there is much appearance of rain. If the fall be sudden, and great for the season, it will probably be followed by thunder.

The *thermometer* is also steady and high, only indicating a great fall during a hail-storm. The *air* is clear and dry in summer, the clouds high, and the wind breezy. The changes from this state are occasioned by thunder and hail storms, and such changes are always sudden and violent.

Animals are numerous in summer, and constantly in the air, and their covering of hair and feathers being peculiarly sensible to the changes of the atmosphere, gives rise to such actions in the animals as are significant of approaching changes in the weather. Ducks, geese, all water-fowl, the guinea-fowl, peacock, crows, frogs, and sparrows, make much noise before a fall of rain. Bees roam but a short distance from their hives, and ants carry their eggs busily before rain. Magpies chatter much before wind. Spiders cover everything with their gossamer when the weather is to continue fine. *Wild-flowers* indicate changes in the atmosphere as sensibly as animals. Chick-weed expands freely and remains open fully, in a continuance of fine weather. When it, with the trefoil and convolvulus, contracts its petals, rain may be expected. Particular forms of *clouds* also indicate both steady and changeable weather, as thus:—

If woolly fleeces strew the heavenly way,
Be sure no rain disturbs the summer day.

When clouds appear like rocks and towers,
The earth's refreshed by frequent showers.

Summer Proverbs.—The metrical *proverbs* of summer are not many.

May.

A cold May and a windy,
Makes a full barn and a findy.

May, comes she early or comes she late,
She'll make the cow to quake.

Beans blow—before May doth go.

A May flood—never did good.

Shear your sheep in May—and shear all away.

A swarm of bees in May
Is worth a load of hay.

Look at your corn in May,
And you'll come weeping away.

June.

Look at your corn in June,
And you'll come home in another tune.

Calm weather in June—sets corn in tune.

July.

A swarm of bees in July—is not worth a fly.

A shower in July, when the corn begins to fill,
Is worth a plough of oxen, and all belongs theretill.

No tempest, good July!
Lest corn come off blew by.

Rainbow Prognostics.—The prognostics connected with the rainbow are: After a long drought the bow is a certain sign of rain; and after much wet, of fair weather. When the green is large and bright, it indicates rain; and when the red is the strongest colour, both wind and rain are indicated. If the bow break up at once, there will follow serene and settled weather. When the bow is seen in the morning, rain will follow; if at noon, settled and heavy rain; and at night, fair weather. The appearance of two or three rainbows indicates fair weather for the present, but settled and heavy rain in two or three days after. Very often only a portion of the arc appears, and it is indicative of rain.

Twilight.—The appearance of twilight depending on the state of the sky, foretells to a certain extent the weather of the following day. When the sky is blue, and after sunset the western region is covered with a slight purple tint, we may expect that the weather will be fair, especially if the horizon seem covered with a slight smoke. When the horizon at sunset is occupied to some height with densely orange-coloured vapour, heavy wind will come in twenty-four or thirty hours. When the horizon at sunset is of crimson or vermilion colour, the wind will be accompanied with heavy rain When the horizon is green at sunset, rain will follow next day. After rain, isolated clouds, coloured red and well illuminated, at sunset, announce the return of fair weather. A twilight of a whitish yellow, especially when it extends to a distance in the sky, is a sign of wet weather on the following day. We may expect showers when the sun is of a brilliant white, and sets in the midst of a white light, which scarcely permits us to distinguish it.

The prognostication is still worse when light clouds, that give the sky a dull appearance, appear near the horizon. When the twilight is greyish red, in the midst of which are seen portions of deep red that pass into grey, scarcely permitting the sun to be distinguished, vesicular vapour is very abundant, and we may calculate on wind and approaching rain.

Daybreak.—The signs drawn from daybreak are somewhat different. When it is very red we may expect rain; whilst a grey morning announces fair weather.

SUMMARY OF SUMMER FARM-WORK.

Calendar and Agricultural Seasons.—Practical farmers know well that farm-work cannot be sharply divided in accordance with the months of the calendar. Indeed the farming seasons, as commonly understood, differ considerably from the calendar seasons. For instance, there are the autumn and spring seed-times, which stretch respectively into winter and summer. It must thus be remembered that in arranging the division of the farm duties in this work it was the agricultural seasons rather than the calendar months that were considered.

Moreover, while it has been deemed prudent to adhere in the main to the original plan of the work in treating of the various operations of the farm as they come round in rotation, we have occasionally departed from the plan for the sake of convenience, or to lessen the amount of repetition, of which indeed, as with actual farm-work itself, there must be a good deal. But in any case, in a work, the practical utility of which is the main consideration, we should never hesitate, for the sake of clearness, to resort to repetition.

Root Sowing.—Early in summer the

land for the root crops is worked, cleaned, drilled, dunged, and sown. The culture of roots is a most important and busy occupation, employing much labour in singling and hoeing the plants for the greater part of the summer.

Fat Cattle.—Feeding cattle not to be put to grass are now got rid of as soon as the state of the markets warrants. There is usually a deficiency of fat cattle for disposal early in summer, the winter supply becoming exhausted before grass-fed animals are fit for slaughter. It is thus a good plan, when it can be carried out conveniently, to have a few fat beasts for sale early in summer.

Fat Sheep.—The fat sheep are also sold, except when desired to have their fleece, in which case they are kept until the weather becomes warm enough for clipping.

Repairing Fences.—Before stock is put on grass, the hedger should mend every gap in the hedges and stone walls, and have the gates of the grass fields in repair.

Grazing Stock.—Young cattle, sheep, and cows are put on pasture, to remain all summer. Cattle and sheep graze well together, cattle biting the grass high, while sheep follow with a lower bite. For the same reason, horses and cattle graze well together. Horses and sheep, biting low, are not suitable companions on pasture. Horses, besides, often annoy sheep.

Horses.—Horses now live a sort of idle life. They escape from the thraldom of the stall-collar in the stable to the perfect liberty of the pasture-field, and there they do enjoy themselves. In the opinion of many farmers it is better for work-horses to have forage at the steading than to be grazed on the fields. The brood-mare brings forth her foal, and receives immunity from labour for a time.

Haymaking.—Haymaking is represented by poets as a labour accompanied with unalloyed pleasure. Lads and lasses are doubtless then as merry as chirping grasshoppers. But haymaking is in sober truth a labour of much toil and heat: wielding the hayrake and pitchfork in hot weather, for a livelong day, is no child's play.

Weaning Lambs.—The weaning of lambs from the ewes is now effected, and marks of age, sex, and ownership are stamped upon the flock.

Forage Crops.—The forage crops on farms in the neighbourhood of towns are now disposed of to cowfeeders and carters.

Dairying.—Butter and cheese are made on dairy-farms in quantities which the supplies of milk warrant.

Weeds.—Summer is the best of all seasons for making overwhelming attacks upon weeds, those spoilers of fields and contaminators of grain. Whether in pasture, on tilled ground, along drills of green crops, amongst growing corn, or in hedges, young and old, weeds should be day by day exterminated. And their extermination is, in many cases, most effectually accomplished by the minute and painstaking labour of field-workers; for which purpose they are provided with appropriate hand-implements.

Insect Attacks.—This is the season in which all manner of insects attack both crops and stock, much to their injury and annoyance.

Fallow Land.—In anticipation of next year's crop, the fallow land is worked, cleaned, manured, and limed, if necessary, in readiness for wheat seed in autumn.

Top-dressing.—Top-dressings of specific manures upon growing crops are applied for the promotion of their growth and fecundity, at the fittest state of weather and crop.

Hours of Labour.—The hours devoted to field-work in summer vary in different parts of the country. In some parts it is the practice to go as early as four o'clock in the morning to the yoke, and the forenoon's work is over by nine, time being given for rest in the heat of the day. The afternoon's yoking commences at one o'clock, and continues till six. Thus ten hours are spent in the fields. But in most parts of the country the morning yoking does not commence till six o'clock, and, on terminating at eleven, only two hours are allowed for rest and dinner till one o'clock, when the afternoon's yoking begins, terminating at six P.M. In some places the afternoon yoking does not commence till two o'clock, and, finishing at six, only nine hours are spent in the fields; or it is continued till seven

o'clock. In other parts, only four hours are spent in the morning yoking, when the horses are let loose at ten o'clock, and, on yoking again from two till six in the afternoon, only eight hours are devoted to work in the fields, the men being employed elsewhere by themselves for two hours.

Many farmers maintain that the best division of time is to yoke at five o'clock in the morning, loose at ten, yoke again at one, and loose at six in the evening, giving three hours of rest to men and horses at the height of the day, and ten hours of work in the field. One drawback to this plan is that the horses have not, without their night's rest being unduly curtailed, had time to feed sufficiently before the day's work begins.

Day-labourers and field-workers, when not working along with horses, often work from seven till twelve, and from one till six o'clock in the evening, having one hour for rest and dinner. When labourers take their dinner to the field, this is a convenient division of time; but when they have to go home to dinner, one hour is too little for dinner and rest between the yokings — and rest is absolutely necessary, as neither men nor women are able to work ten hours without an interval of more than one hour. It is a better arrangement for field-workers to go to work at six instead of seven, and stop at eleven instead of twelve, when they have to go home to dinner.

When field-workers labour in connection with the teams, they must conform with their hours.

Rest.—The long hours of a summer day, of which at least ten are spent in the fields—the high temperature of the air, which suffuses the body with perspiration—and the oft-varying character of field-work in summer, bearing hard both on mental and physical energies, cause the labourer to seek rest at an early hour of the evening. None but those who have experienced the fatigue of working in the fields, in hot weather, for long hours, can sufficiently appreciate the luxury of rest—a luxury truthfully defined in these beautiful lines :—

"Night is the time for rest.
How sweet, when labours close,
To gather round the aching breast
The curtain of repose—
Stretch the tired limbs, and lay the head
Upon one's own delightful bed!"

JAMES MONTGOMERY.

The Farmer's Duties.—Every operation, at least early in summer, requires the constant attention of the farmer. Where natural agencies exert their most active influences on animal and vegetable creation, he requires to put forth his greatest energies to co-operate with the very rapid changes they produce. Should he have, besides his ordinary work, field experiments in hand, the demands upon his attention and time are the more urgent, and he must devote both assiduously if he expect to reap the greatest advantage derivable from experimental results.

The Farmer's Holiday. — Towards the end of summer is the only period in which the farmer has liberty to leave home without incurring the blame of neglecting his business. Even then the time he has to spare is very limited. Strictly speaking, he has only about two or three weeks before the commencement of harvest, in which to have leisure for travel. A journey once a-year to witness the farm operations of other parts of the kingdom, or of foreign countries, enlightens him in many uncertain points of practice. He there sees mankind in various aspects, his mind becomes widened and raised above local prejudices, and a clearer understanding of places, manners, and customs is afforded him when reading the publications of the day. A month so spent may, in its experience, be worth a lease-length of local reading and of stay-at-home life.

HAY-STACK FOR HORSES.

It is the custom in many parts not to break upon the hay-stack until the busy work of spring has begun. This, however, will depend upon the supply of other food for horses, such as good oat-straw or good bean-straw. When these are plentiful, little or no hay may be used till well into spring.

Taking in Hay.—As much of the hay-stack is brought in at a time as will fill the hay-house. Each portion of

the stack cut off from its top, 4 or 5 feet in breadth, should have its covering removed, and the remainder on the stack firmly secured, otherwise the wind may blow it away entirely.

Hay-knife.—The implement used for cutting hay is the hay-knife, fig. 338, which is a convenient form. It will be observed that the line of the back of the blade is not at right angles to the handle, a position which gives the cutting edge of the knife an inclination to the line of section, and consequently affords it, in its downward stroke, a force to cut the successive straws of hay, which it could not do were the stroke perpendicular to the length of the blade. The person who cuts the stack is the steward, and in using the knife he kneels upon the part he is cutting off, with his face to the body of the stack.

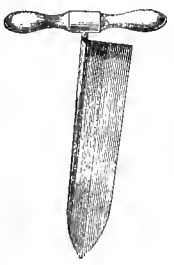


Fig. 338.—*Hay-knife.*

This form of knife requires considerable force in its use, and unless the edge is kept keen with a whetstone, and the hay firm, it makes bad work.

A hay-knife which some prefer is in the form of the dung-spade, which, being used standing, is wielded with much greater force, and makes a deeper cut; and having two sharp sloping edges, it cuts equally well to the right or left.

A very expeditious form of hay-knife is that shown in fig. 339. (J. G. Rollins & Co., Ld., American merchants, Old Swan Wharf, London.)

Method of Cutting a Hay-stack.—In cutting off a breadth of hay across the stack, the stack should be left perpendicular and the cutting horizontal. When the dace is not cut down to the ground, straw should be placed upon the cut portion left, to protect it from rain, and a hurdle or two placed upon the straw to prevent it being blown off. The hay is usually conveyed to the hay-house in a cart, as in the case of grain to the sheaf-barn.

Hay for Young Horses.—Young horses should receive hay after the stack has been broken into, straw becoming too hard and dry after March. Moreover, it is expedient to improve their condition to prepare them for grass.

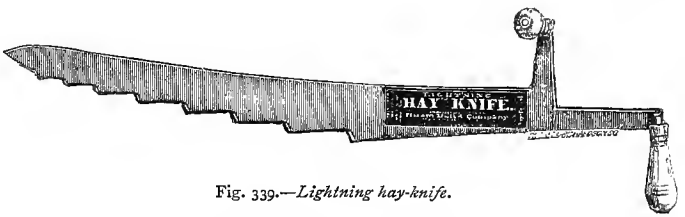


Fig. 339.—*Lightning hay-knife.*

Feeding cattle rarely receive hay in Scotland, but in England meadow-hay is given to feeding cattle either alone, with some straw, but more frequently chopped hay and straw together, or in union with oilcake, or with linseed prepared. On dairy-farms, cows generally receive hay after having calved, either as steamed chaff or dry fodder.

FLAX CULTURE.

Flax (*Linum usitatissimum*, Nat. Order *Lineæ*) is cultivated for fibre or for seed, or for both. In this country it is cultivated most largely in the north of Ireland, where it is grown with great success to supply fibre to the extensive linen-mills of Ulster. The Irish farmers both grow the crop and prepare the fibre for the linen-mills. In most other parts, notably on the continent of Europe, the farmer merely grows the crop and leaves its manipulation to others. In order to obtain the finest fibre the flax has to be pulled before the bolls or seed are ripe, and thus a twofold return of seed and fibre is seldom obtained from the one crop.

As already explained (vol. i. p. 257), linseed, the seed of flax, possesses great

value as an article of food, especially for cattle.

Soil for Flax. — The flax plant requires a deep mellow loamy soil, abounding in vegetable matter, and equally removed from strong clay and thin gravel. On clay the plant grows too strong and branchy, yielding coarse fibre, and on gravel it is stinted in growth. Any soil in too high condition causes flax to be rank, branching, and coarse.

Rotation for Flax.—The finest flax is best obtained after corn or potatoes. In the north of Ireland, where flax cultivation is pursued extensively and with great success, it is not considered good practice to grow flax after lea. It is difficult to get lea-land into a sufficiently fine tilth, and insect attacks are more frequent after lea than after wheat or potatoes. Flax should not follow turnips, but it does well after potatoes. Flax should not be repeated on the same land at shorter intervals than about seven years; some say nine years would be better still. Flat land is preferable to undulating, hilly uneven land rarely producing flax of a uniform reed.

Tillage for Flax. — Whether after cereals or lea, the land for flax should be ploughed early in winter, to receive the full effects of the frost. It cannot be in too fine a state of pulverisation when the seed is sown. To promote this fine state of the soil, cross-ploughing should be executed early in spring, taking care to avoid wet weather, or the soil in a waxy state, as dry weather following renders the soil difficult to be pulverised. Clods left on the surface, after a double turn of the harrows, should be reduced by a clod-crushing implement.

The cross-ploughing in spring should be done about two months before sowing. Medium land after potatoes will do with one ploughing from four to six weeks before sowing. Heavy land after potatoes should be ploughed as early in the year as possible. Plough shallow, about 4 inches deep, after potatoes. It is recommended that as far as possible weeds should be removed by forks and graips before the seed-bed is prepared. Flax delights in a firm, even seed-bed, and if the land is dry naturally or well drained, it thrives best broadcast or in rows on the flat. In drills it is more apt to be uneven in length, and it is very important that flax should be as uniform in length as possible. Light land should not be too much stirred, but heavy land cannot be too much pulverised.

Clod-crushers. — Crosskill's clod-crusher, shown in perspective in fig. 340,

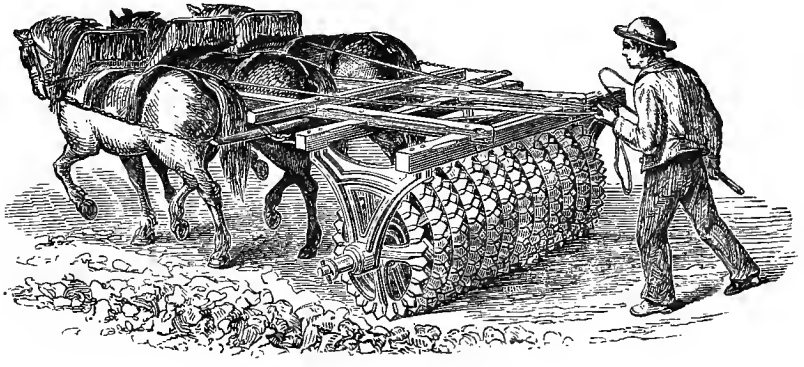


Fig. 340.—*Crosskill's clod-crusher.*

is a most efficient implement. The roller consists of a number of toothed wheels, supported on feathered arms, and an eye formed in the centre fitted to move easily on the axle of the roller. Fig. 341 shows a side view of one of those wheels, by which its action upon the soil may be easily understood.

When such a great number of angles, acting like so many wedges, are brought into contact with the indurated clods, they infallibly split them into numerous

fragments, and the repetition of the process produces a well-pulverised surface. The effect is quite different from that of the plain roller, by which, if a clod does not crumble down at once with its pressure, it is forced into the soil in a solid state.

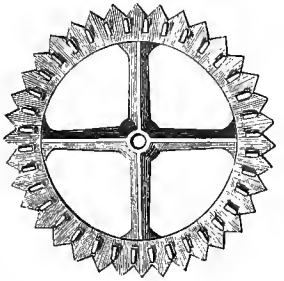


Fig. 341.—*Side view of one wheel of the clod-crusher.*

This clod-crusher has been but partially used by Scottish farmers, though extensively in use in England—perhaps on account of the greater extent of clay soils there, which are always subject to induration by drought. Where the implement has been tried in Scotland, the results have proved equally favourable on strong and light soils—in pulverising the strong and consolidating the light.

Norwegian Harrow.—Another very useful pulverising implement is the Norwegian harrow, shown in fig. 342, and made by C. Clay, Wakefield. The action of this machine is to reduce large clods into very small ones, by the insertion of the points of the rays into them, to split them into pieces by their reiterated action. The larger clods are split into smaller pieces by the first row of rays, the second row splits these into smaller ones, and the third row splits those smallest pieces into still smaller ones; so that, by the time the clods have undergone those various splittings, they are probably sufficiently pulverised.

Sowing Flax.—The time for sowing flax will of course depend partly on the climate of the district and on the charac-

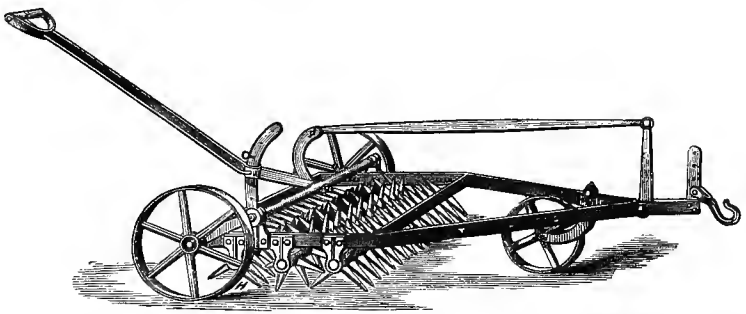


Fig. 342.—*Norwegian harrow.*

ter of the particular seasons. As a rule, from the last week in March till the third week in April is the flax seed-time. The young flax plants, if the sowing has been done too early, are liable to injury from frosts, which cause the plant to branch, thereby greatly lessening the value of the crop.

Prepare a fine, smooth, firm seed-bed with the harrow and roller. Some harrow, roll, and then sow; others harrow, roll, and harrow again, and then sow. Mark off the land on the flat for the casts of seed with poles or footprints. In some cases, to facilitate weeding, it is sown in rows 8 to 10 inches apart, but generally broadcast.

Seed.—Dutch seed is best suited for heavy soils and after green crop, and Riga seed for medium and light lands. The former produces the finer fibre, and is usually cleaner than the Riga seed. The latter, indeed, should invariably be put through a flax-seed sieve, made for the purpose of perforated zinc, before being sown, as thereby considerable trouble in removing weeds may be saved.

As to the quantity of seed, if the crop is grown for the fibre, from 2 to 2½ bushels per acre should be allowed; if for seed, 1½ bushel will suffice. Flax seed is sown by the hand, but as the seed is very slippery it must be done by a skilful person. The seed should be taken hold of by the thumb and two

foremost fingers, like grass seeds, and thrown forward in sharp casts, with short quick steps, and being dark-coloured, is easily observed to fall upon the rolled ground in regular broadcast. A strip with a light harrow will suffice to cover the seed. Flax seed is oblong lenticular in shape, having a smooth oily surface, feels heavy, and should be plump and fresh. As good seed is of great importance in the success of this crop, flax seed beyond a year old should never be sown.

Grass Seeds with Flax.—Land is frequently sown out into grass with the flax crop. Italian rye-grass is injurious to the flax on account of its vigorous growth, but perennial rye-grass, clovers, and natural grasses may be sown with impunity. These should be sown immediately after the flax seed, and the two harrowed in together with a light harrow. If it is desired to have Italian rye-grass after flax, the seed may be sown as soon as the flax is pulled in July.

As a catch-crop for districts where the climate is suitable, scarlet clover (*Trifolium incarnatum*) may be sown when the flax is pulled, and this will provide a useful cutting in the following May, after which the land may be prepared and sown with turnips. Others sow rape or winter vetches and rye after flax for spring food for stock.

Top-dressing Flax.—Although the flax crop does not bear being sown upon dung, a top-dressing of bone-dust of 10 or 12 bushels to an acre, after a white crop, may often be given with advantage, especially if the crop is making slow progress.

But the best plan for flax is to have the land in high condition from previous manuring, so that top-dressing may not be necessary. The Belgians profusely top-dress their flax-ground with liquid manure (in which have been dissolved both rape-cake and nightsoil), to the amount of 2480 gallons to one acre.[1]

Weeding Flax.—The only attention which the flax crop requires in summer is to keep it free from weeds. These will appear as soon as the crop itself; and when the crop can be identified from them, the ground should be weeded. Being in broadcast, and thickly sown, the only practicable way of weeding flax ground is by the hand. As the plant is firm and elastic, the stem is not injured by the weeders treading on it, if they are careful. The weeders should not wear shoes, so as to avoid injuring the flax. The weeding should be done effectually, and at intervals, till the plants are from 4 to 7 inches high. Close hand-weeding is costly, but the increase of crop will more than repay the outlay.

Besides the common surface and root weeds which infest the soil, there are others special to flax; as Gold of Pleasure, *Camelina sativa*, the seed of which is imported among the flax seed; the flax-dodder, *Cascuta europœa*, which adheres parasitically to the flax plant, and materially injures its fibre. "It is a plant," says a writer, "which germinates in the ground, and sends up a slender threadlike stem, which, twisting itself about, soon touches one of the stems of the flax amongst which it is growing. As soon as this takes place, the dodder twists itself round the flax, and throws out from the side next to its victim several small processes, which penetrate the outer coat or cuticle of the flax, and act as suckers, by which *the parasitical dodder appropriates to its own use the sap which has been prepared in the flax, upon which the growth of the flax depends.* The dodder then separates itself from the ground, and relies solely upon the flax for its nourishment, producing long slender leafless stems, which attach themselves to each stem of flax that comes in their way. Thus large masses of crop are matted together, and so much weakened as to become almost useless. This plant produces great quantities of seed, which is usually threshed with the flax seed, and sown again with it in the succeeding year. Several years since, I took considerable trouble to ascertain if all foreign flax seed was mixed with that of the dodder, and was led to the conclusion that the American flax seed is nearly free from this pest, and that that from Russia, and especially from Odessa, is peculiarly infected with it."[2] A thorough weeding will remove this pest from the soil before it has the power of injuring the flax plant.

[1] Radcliff's *Agric. Flan.*, 42.

[2] *Garden. Chron.*, Feb. 10, 1844, 189.

From the time the weeding is finished the crop needs no further attention till the pulling time approaches, usually in July.

PULLING, STEEPING, AND DRYING FLAX.

Pulling.—The flax plant is pulled up by the root. The pulling is done after the plant has flowered and the seed attained a certain degree of maturity in the capsule or boll which contains it. As to the proper time to begin pulling, great care and judgment must be exercised. If pulled too soon the fibre will be weak; if allowed to ripen too much, the fibre will be dry and coarse.

The test for pulling, according to Henderson, is this: "I have found the test recommended by Boss, to ascertain the degree of ripeness that gives the best produce with the finest fibre, perfect. It is this: Try the flax every day when approaching ripeness by cutting the ripest capsule on an average stalk across, horizontally, and when the seeds have changed from the white milky substance which they first show to a greenish colour, pretty firm, then is the time to pull. The old prejudice in favour of *much ripening is most injurious*, even as regards quantity; and the usual test of the stalk stripping at the root and turning yellow, and the leaves falling off, should not be depended on. Where there is one man that pulls too green, 500 over-ripen."

Method of Pulling.—When thus ripe, the flax should be pulled in this way, as described by Henderson: "I use the Dutch method, by catching a few stems of the flax at a time close below the bolls, which allows the shortest of the flax to escape. With the next handful the puller draws the short flax, and keeps the short and the long each by itself, to be steeped in separate ponds. It is most essential to keep the flax *even* at the root-end, and this cannot be done without time and care; but it can be done, and *should always be done*. The *beets* or sheaves should always be small, equal-sized, straight and even, and should never be put up in stooks or windrows, but taken to the pond the day they are pulled, or the day after at longest, especially in bright weather; for the discoloration produced by the sun on green flax will never be removed till it goes to the bleacher, and will give him some trouble also."

Rippling.—On being pulled, the plant is deprived of its bolls or seed-capsules by rippling, which consists of drawing the head or boll end of the stem through the teeth of an iron comb 8 inches in length, set upright upon a form, across which two men sit opposite each other, and ripple their handfuls alternately, the bolls falling on a barn-sheet spread under the form.

Another convenient arrangement is to have the comb bolted to a plank, securely fastened to the body of a cart from which the wheels are removed. When the cart is full of bolls or seeds, raise it on to the wheels and remove the bolls to where they can be dried.

The arrangement of labour should be such that the rippling goes on simultaneously with the pulling. The rippled plants should be tied in sheaves, to be taken to the watering-pool to be steeped. Some steep the bolls on the plants, but no good is attained thereby.

The Bolls.—The green bolls or seed should be at once spread over lofts to dry. Turn them frequently, and when partially dry they are taken to a corn-mill and finished on the kiln moderately heated.

Steeping.—Next comes the steeping, a most important process. The object of steeping the flax plant is to separate the outer fibre of the stem from the interior pith by disintegration. The adhesive substance between the fibre and pith is mucilage, which is the sooner dissolved the sooner the plant is steeped. If steeping is so long continued as to affect the texture of the fibre, the flax will be injured; and should it not be continued until the pith may be easily loosened, much labour will be required to get rid of it.

Proper steeping, then, is not only an essential, but a nice process, and clear instructions regarding it should be scrupulously followed. Henderson says: "The water brought to the pond should be pure from all mineral substances, clean and clear. The water from large rivers is generally to be preferred; but spring-water which has run some hundred yards becomes soft, and will have deposited

any mineral impurities it may have contained; but that immediately from the spring seldom does well. If the water be good and soft, it is injurious to allow it to stagnate in the pond before being used for steeping. I put in two layers, each somewhat sloped, with the root-end of each downwards: one layer at a time is said to be safer, and perhaps is so, although I have tried both ways, and have observed no difference. The flax should be placed rather loose than crowded in the pond, and laid carefully straight and regular. Having an abundant supply of water, I do not let any into the pond till the first layer is first placed in it. I cover the flax with sods laid perfectly close, the shear of each fitting to the other. Thus covered, it never sinks to the bottom, nor floats above the water, nor is affected by air or light. It is generally watered in eleven or thirteen days. A gentle stream should, if possible, always pass slowly over the pond; it carries off impurities, and does not at all impede due fermentation. Flood and impure water should be carefully kept off; and perhaps the best way to do this is to make a drain or ditch around the pond. The greatest cause of injury in steeping is exudation of water from the sides or bottom of the pond. Stripe and discoloration are mostly imputed to the quality of the water brought to the pond; whilst in most cases the water oozing from the sides and bottom of the pond itself is the cause. Even if such water were pure, which it seldom is, it is injurious; but when impregnated with iron or other materials, it does immense harm. If such ponds must continue to be used, the injury may be partially amended by draining around the sides and ends, at 6 or 8 feet distance, and 18 inches deeper than their bottom, and filling the drains with tiles or stones. No other thing I know of does so much injury as this springing of water within the pond."

Water deeply tinged with iron is certainly very injurious to the flax; but a slight tinge of iron in the only supply of water available should not prevent a farmer from growing flax, if the conditions otherwise are favourable.

The utmost care should be exercised in deciding when the flax has been sufficiently watered. The Dutch test which is recommended by many authorities is thus described by Henderson: "Try some stalks of average fineness by breaking the woody part in two places, about 3 inches apart, at the middle of the length; catch the wood at the lower end, and if it will pull downward freely for those 3 inches, without breaking or tearing the fibre, it is ready to be taken out. This trial should be made every day after fermentation subsides, for sometimes the change desired is rapid. Flax is more frequently injured by too little than too much of the water."

Drying. — Continuing, Henderson says: "Great care and neatness are necessary in taking the flax out, as broken or crumpled flax will never reach the market. Set the sheaves on end against one another as taken out of the pond, to drain the water off them the more quickly. Spread the flax on the same day it is taken out, unless it happens to be heavy rain. Light rain does little harm; but, in any case, spread the next day, for it will heat in the pile, and that heating will be destructive."

Flax "should be *spread* even, straight at its length, not too thick, and well shaken, so that there shall be no clots; indeed, if possible, no two stalks should adhere. I have ever found it injurious to keep it long on the grass: it is in the steep the wood is decomposed; on the grass the fibre is softened, and the wood little, if at all, affected. I rarely let it lie more than five days, sometimes only three: one year it had only three days, and I never had better flax. It should never, if possible, be spread upon the ground where it has grown — it claps down, and the clay and weeds discolour it: clean lea, or lately cut meadow, is the best ground."

When it has to lie long on the grass owing to rainfall, the flax may occasionally suffer from mildew. To guard against this it is deemed advisable by some to lift the flax in handfuls by the boll end, and set it up on the root end in the form of a hollow cone, with the boll ends twisted a little to keep the cone together. But in the case of high winds following this practice, the flax is liable to injury by being blown about.

Lifting. — "Lifting, like all other operations, requires care and neatness

to keep the flax straight in its length, and even at the roots. This operation is too frequently hurried and coarsely done. If the steeping and grassing have been perfect, flax should require no fire; and to make it ready for breaking and scutching, exposure to the sun should be sufficient; but if the weather be damp, the flax tough, and must be wrought off, then it must be fire-dried. Such drying is always more or less injurious; and if it be put on the kiln in a damp state, it is ruinous—it is absolutely burnt before it is dry. All who can afford it should keep such flax over to the ensuing spring or summer, putting it dry into stacks, when it will work freely without fire-heat.

"The proper culture and preparation of flax require more care, exertion, and expense than the old slovenly method; and those who will not give those requisites, would do wisely to abstain from growing flax altogether. Any other crop will abide more negligence. Flax is proverbially either the very best or the very worst crop a farmer can grow." [1]

Scutching.—This is more distinctly a part of the manufacturing process, and therefore does not come within the scope of this work.

Growing and Saving Seed. — The late Mr Michael Andrews, Secretary of the Flax Supply Association for the Improvement of Flax in Ireland, contributed an instructive paper on Flax Culture to the 'Journal of the Royal Agricultural Society of England' in 1881. Those who may desire fuller information on the subject would do well to consult that paper.[2]

In regard to flax seed, the supply of which is principally foreign, Mr Andrews says: "In this climate home production would be too precarious to depend on; and another consideration is, that to treat flax so as to save seed suitable for sowing reduces the quality of the fibre. The saving of seed for sowing, however, is not sufficiently attended to in Ireland, and it would be desirable that growers of flax should reserve a small portion of each year's crop for seed—of course assuming that the crop is grown from Riga seed. The portion set apart for seed production should be sown rather thinner than that from which no sowing-seed is intended to be taken, and it should be allowed to ripen on the foot. Poor stunted spots often occur in flax-fields which might be judiciously left to mature, and save the seed therefrom.

Selecting Seed. — "Seed must be selected by its appearance, choosing it of a bright colour and plump, and as free as possible from imperfect pickles; but even with all these characteristics the farmer may not procure a really good article. The surest method of obtaining genuine seed is to purchase a known brand from a reliable importer."

Old Seed.—It is said that in Belgium two-year-old seed is preferred to new. Mr Andrews prudently observes, however, that "no seed beyond one year old should be sown without testing its vegetating power."

Manurial Value of Flax-pond Water.—It has been believed by many that the water in which flax has been steeped possesses considerable manurial value. This, however, is very doubtful, and would not likely repay the cost of pumping and distributing.

FLAX-GROWING IN GREAT BRITAIN.

It is at first sight somewhat strange that a crop which is grown with financial success in Ireland and in many foreign countries should have never come into culture in England and Scotland.

Formerly Grown. — For domestic purposes very small patches of flax have been grown in some parts of England and Scotland for a very long time. But it has never taken rank in these countries as an ordinary farm crop. Indeed even the small patches of flax or lint for domestic use have in most cases become things of the past. The "lint-pools," once dotted pretty freely over Scotland, have nearly all disappeared, and many of the Scotch and English farmers of the present day have never seen a stem of flax growing.

Recent Trials.—Between 1880 and 1887 there was a good deal of discussion as to the propriety of introducing flax as a farm crop in England and Scotland. In several parts of the country the crop has

[1] Henderson's *Cult. of Flax*, 1.

[2] *Jour. Royal Agric. Soc. Eng.*, sec. ser., vol. xvii., part 2, 408.

been tried upon small patches, but the results financially have not been sufficiently good to warrant any great extension of the enterprise.

Outlet for Flax Straw.—The main hindrance to the successful cultivation of flax in England and Scotland is the want of a profitable outlet for the flax straw. In the north of Ireland flax-growing flourishes because, in the extensive linen-mills of that industrious province of the Green Isle there is a sure and ample demand for the straw. There, indeed, flax is grown almost for the sole purpose of supplying flax fibre to these linen-mills. The two industries go hand in hand, the one being essential to the success of the other. Little attention is given to the seed, for the reason that, by allowing the seed to ripen, the fibre of the flax, the main concern of the Irish flax-grower, would be somewhat injured in quality.

It has been well shown in the various trials conducted that the climate and soil in most parts of Great Britain are well suited for the successful growth of both flax straw and flax seed. The unfortunate thing is that, until a better market can be found for the straw, the value of the crop when it is grown is not sufficient to adequately remunerate the grower.

Uses of Flax Seed.—For flax seed, or linseed, as it is more commonly known, there will always be a reliable and satisfactory market. Its high feeding properties are well known, and it is an article which is easy of transport.

Uses of Flax Straw.—With the flax straw the case is different. It makes admirable thatch, but the demand for this purpose would never be worth reckoning. Its most remunerative use is the manufacture of linen. Unfortunately in England and Scotland there is no such demand for it for this purpose as there is in Ulster. Whether or not the demand may arise, or could be raised up by any concerted action, is a very doubtful point.

Flax Straw for Paper-making.—Flax straw is also adapted to the manufacture of paper. Its value for this purpose, however, is kept severely in check by the abundance of other commodities which are more suitable, and which—by the processes of manufacture now known—can be manufactured at less outlay. It is just possible that methods of paper-making may yet be discovered which will provide a remunerative outlet for flax straw in that ever-growing industry.

Experiments in Flax-growing.

An interesting experiment in the growing of flax as a farm crop was carried out by Mr Richard Stratton, The Duffryn, Newport, Monmouth, beginning in 1880. He was induced to make the trial by Mr Reed, manager of the Ely paper-works, Cardiff, who had been using flax straw in the manufacture of paper, and who agreed to pay Mr Stratton £4, 10s. per ton for the flax straw, straight from the threshing-machine.

For his first crop Mr Stratton selected a field of eight acres, a sandy loam of moderate depth resting on gravel. In the previous winter (1879-80) about 15 tons of farmyard manure per acre had been ploughed in. Having previously grown three successive crops of oats, the land was in poor condition. In the spring of 1880 the field was twice scarified and dragged, and in the second week of April the flax seed was sown, 1½ bushel of seed per acre being drilled in eight inches apart. The crop was weeded at a cost of about 2s. per acre, and about a week after the wheat, it was ready for harvesting, the pulling, tying, and stooking costing £1 per acre. Wild vetches and "goose grass" spoiled some patches, yet the eight acres gave the following return :—

Yield per acre.	Value per acre.
22 bushels seed at 8s. .	£8 16 0
32 cwt. straw at 4s. 6d. .	7 4 0
	£16 0 0

This result was so satisfactory that Mr Stratton decided to repeat the experiment upon a larger scale. A field of 21 acres, of similar soil, also poor and foul, from having borne eight consecutive hay crops followed by spring wheat, was selected for the second trial. It was well tilled and cleaned in the autumn and spring, manured with 7 cwt. of damaged decorticated cotton-cake per acre, and sown, about the middle of April, with 1½ bushel of flax seed. Hand-hoeing this time cost 5s. per acre. This crop came up admirably, and although there was a little shedding of seed, owing to wet weather having delayed harvesting,

the return was again satisfactory. It was as follows:—

Yield per acre.	Value per acre.
40 cwt. straw at 4s. 6d. .	£9 0 0
20 bushels seed at 8s. .	8 0 0
	£17 0 0

A third experiment was not so satisfactory. It was on tenacious soil, on the Old Red Sandstone formation. The previous crop was swedes, eaten off, for the most part, by ewes and lambs without any cake or corn. The land was not ploughed until the end of April, and then it could not be reduced to that fine tilth so essential for flax. The flax seed was sown at the rate of one bushel per acre about the 7th of May. Dry weather followed, and the crop came up much too thin, giving the following poor return:—

Yield per acre.	Value per acre.
15 bushels seed at 8s. .	£6 0 0
16 cwt. straw at 4s. 6d. .	3 12 0
	£9 12 0

This result is indeed only what might have been expected under such untoward circumstances, especially in view of the rough state of the ground. The ground was in such bad condition, and the season so unfavourable, that a crop of wheat on the other half of the same field realised only £6 per acre for both corn and straw.

Mr Stratton induced his friend, Mr T. R. Hulbert, North Cerney, Cirencester, to try a small field of flax on a poor shallow piece of soil, high on the Cotswold Hills. The preceding crop on this land was roots, eaten off by sheep, which had an allowance of corn as well. The seed (1½ bushel per acre) was sown in the first week of May. The crop produced 20 bushels of seed and 1 ton of straw per acre. For this Mr Hulbert realised £14, 10s. per acre—just about double the value of the corn crops on his farm in that very bad year—1881.

With these prices for the produce—8s. per bushel for seed, and £4, 10s. per ton for straw—Mr Stratton was thoroughly satisfied that flax would be more profitable to the grower than corn.

Advantages of Flax over Corn.—The advantages which, with the above prices, Mr Stratton claimed for flax over corn were stated by him as follows:—

1. More profitable.
2. Far less risky, being virtually rain-proof.
3. Being generally a new crop, it is an entire change for the land, and therefore desirable.
4. However strong the land may be, flax will not lodge seriously, unless pulled down by bind-weeds; so that on the land where barley would certainly be too heavy, flax may be grown without any danger of that kind.
5. Birds do not touch it at planting-time, though, when ripe, finches are very fond of it.
6. It may be planted later than spring corn, thus affording more time to clean the land.
7. It may be grown on land that cannot be depended upon to produce malting barley.
8. I believe it is practically proof against wire-worm.
9. Rabbits and hares do not eat it, though they will occasionally cut roads through it.[1]

Disadvantages of Flax over Corn.—On the other hand, Mr Stratton found that the cultivation of flax cost about 10s. per acre more than wheat or barley, and harvesting also about 10s. more, while threshing flax by the ordinary threshing-machine was likewise rather more costly than the threshing of the common corn crops. Then the flax straw, being sold instead of consumed on the farm, costs perhaps 10s. per ton for delivery. These extra outlays, as compared with corn-growing, Mr Stratton estimated at 35s. per acre, which—with 8s per bushel for flax seed, and £4, 10s. per ton for flax straw—was far more than repaid by the greater value of the flax crop.

Loss of the Market for Flax Straw.—In the interesting account of his experiments which he published in the Journal of the Royal Agricultural Society of England, Mr Stratton explained clearly that the success of flax-growing in lieu of corn culture depended mainly upon whether or not the demand for flax straw for paper-making at the price of about £4, 10s. per ton would be maintained.

1 *Jour. Royal Agric. Soc. Eng.*, sec. ser., xviii. 461.

This, unfortunately, has not been the case. The paper-makers, as has already been indicated, found a cheaper substitute for the flax straw in the "waste" from flax-mills, and owing to the loss of this market for the straw, Mr Stratton had to give up the growing of flax.

Will the Market return?—Whether or not a sufficient demand will open up again for flax straw for paper-making is uncertain. As to the probability of resuming the growing of flax, Mr Stratton, writing in 1889 to the editor of this work, says, "I am quite prepared to go on growing flax now, if I can get a fair market for the straw. I am strongly of opinion that it ought to be grown to a much greater extent in England than is done at present. I am fully persuaded that no country is better suited to it, either in regard to soil or climate, than the United Kingdom; and it does seem strange that while we grow almost none, all nations grow it, and send both seed and fibre here."

Flax Straw displaced.—In response to an application for information as to the circumstances which have led to the depreciation and disuse of flax straw in the manufacture of paper, Mr A. E. Reed courteously replied to us as follows, under date October 19, 1889:—

"When a few years back I arranged with Mr Stratton to grow some flax for the works of which I was then manager, esparto, straw, and rags were the fibres principally employed for making paper for cheap newspapers, together with a certain quantity of mechanically prepared wood pulp. At that time esparto (of which a larger quantity was used than any of the other fibres named), was standing at about £6 per ton for the cheapest sort, and went up indeed to £7. Flax straw not yielding so much fibre, and requiring more chemicals for its treatment than esparto, was not worth so much. I estimated its value to be about £2 per ton below esparto, and agreed to pay Mr Stratton £4 10s. per ton. But the high price of esparto stimulated the working out of processes for the chemical treatment of white pine wood, and the success of the methods employed has resulted in raw wood becoming largely used. In fact, at the mill which I am now managing nothing but wood is used, and the paper made is suitable for fine printing and other papers. This wood can be delivered to English ports at about 30s. to 35s. per ton; and I consider it is quite equal to flax straw, except that it requires rather more expensive treatment, whilst the yield of fibre is about the same. Flax straw is therefore bowled out, except in districts where wood is not easily obtainable, and even then the use of the wood has operated to bring down the price of all other fibres. Esparto (cheapest kind) is now worth about £3, 15s. per ton, and straw is much cheaper than formerly; so also are rags and all other fibres. And I see no prospect of any change. The supply of wood is abundant.

"I think, however, there is an opening for improved methods of treating flax straw for producing fibre for textiles; and those interested should turn their attention to that. At present the flax used in this country is mostly imported."

The Flax Plant.

The flax plant is stated to be a native of Britain; and yet flax seed was not sown in England until A.D. 1533, when it was directed to be sown for the making of fishing-nets.[1]

Ure says of the flax plant: "In it two principal parts are to be distinguished—the woody heart or boon, and the *harl* (covered outwardly with a fine cuticle), which encloses the former like a tube, consisting of parallel lines. In the natural state, the fibres of the harl are attached firmly not only to the boon but to each other, by means of a green or yellow substance. The rough stems of the flax, after being stripped of their seeds, lose in moisture, by drying in warm air, from 55 to 65 per cent of their weight, but somewhat less when they are quite ripe and woody. In this dry state they consist, in 100 parts, from 20 to 23 per cent of harl, and from 80 to 77 per cent of boon. The latter is composed, upon the average, of 69 per cent of a peculiar woody substance; 12 per cent of a matter soluble in water; and 19 per cent of a body not soluble in water, but in alkaline lyes. The harl contains, at a mean, 58 per cent of pure

[1] Haydn's *Dict. Dates*—art. "Flax."

flaxen fibre, 25 parts soluble in water (apparently extractive and albumen), and 17 parts insoluble in water, being chiefly gluten. By breaking the harl with either hot or cold water, the latter substance is dyed brown by the soluble matter, while the fibres retain their coherence to one another. Alkaline lyes, and also, though less readily, soap-water, dissolves the gluten, which seems to be the cement of the textile fibres, and thus set them free. The cohesion of the fibres in the rough harl is so considerable, that by mechanical means—as by breaking, rubbing, &c.—a complete separation of them cannot be effected, unless with great loss of time and rupture of the filaments. This circumstance shows the necessity of having recourse to some chemical method of decomposing the gluten. The process employed with this view is a species of fermentation, to which the flax stalks are exposed. It is called *retting*, a corruption of rotting, since a certain degree of putrefaction takes place." [1]

"James Thomson and Bauer have shown that the *fibres* of flax are transparent cylindrical tubes, articulated, and pointed like a cane; while the filaments of cotton are transparent glassy tubes, flattened, and twisted round their own axis. A section of a filament resembles, in some degree, the figure 8, the tube, originally cylindrical, having collapsed most in the middle, forming semi-tubes on each side, which give to the fibre, when viewed in a certain light, the appearance of a flat ribbon, with a hem or border on each edge. The uniform transparency of the filament is impaired by small irregular fissures, probably wrinkles arising from the desiccation of the tube. In consequence of this difference between the structure of linen and cotton fibres, Thomson and Bauer were enabled to ascertain that the cloth in which the Egyptian mummies are wrapt is always linen, and never cotton. It is clear from this that the opinion entertained by some, that what is called in our translation of the Old Testament *fine linen* of Egypt ought to be the *cotton cloth* of Egypt, is erroneous. We have no evidence from the cloth wrapt about ancient mummies that the Egyptians in those early times were acquainted with cotton." [2]

Flax is manufactured into twine, rope, and thread, and into fabrics, varying in texture from coarse bagging, employed to pack cotton or hops, to canvas, linen, cambric, and finest lawn.

"Formerly the seed of the flax was occasionally used with corn to make bread; but it was considered hard of digestion, and hurtful to the stomach. In a scarcity of corn which happened in Zealand in the sixteenth century, the inhabitants of Middleburgh had recourse to linseed, which they made into cakes, and which caused the death of many of the citizens who ate of it, causing dreadful swellings of the body and face." [3]

HEMP CULTURE.

Hemp (*Cannabis sativa*, natural order *Urticaceæ*) is grown to a very limited extent in this country, chiefly in the counties of Lincoln and Dorset. The climate of Scotland does not suit it. It grows best in deep rich moist alluvial soil. Its mode of culture is in several respects similar to that of flax. Hemp responds well to a heavy dose of dung, the finest fibre being grown after a dressing of about 20 tons of dung, applied in the autumn before sowing.

Hemp is sown towards the end of April, in rows about 18 inches apart, with 3 to 5 pecks of good seed per acre. The plants are thinned out in the rows to nearly a foot apart. The plants throw up a rapid and bulky growth, so that little weeding early in the season is sufficient to keep the land clean. The crop is pulled, stacked, and steeped similarly to flax. The object of the steeping in water, of course, is to rot away the woody part of the stem and separate the fibre.

When the crop is growing, the ground should be watched after sowing until the plants are in leaf, to keep off birds of the finch tribe, which are very fond of hemp seed. Even the young plants are injured by them — the capsules of the seed, being brought above ground by the

[1] Ure's *Dict. of the Arts*—art. "Flax."

[2] Thomson's *Org. Chem.*—"Veget.," 849.

[3] Phillip's *Hist. Culti. Veget.*, i. 208.

embryo, are greedily devoured by those birds. Care should be taken in weeding not to break the young plants, as, if broken, they will never rise again.

A good crop of hemp yields about 16 bushels of seed, and from 6 to 8 cwt of fibre per acre.

The hemp plant has the male and female flowers on different plants. The male plants are recognisable by the difference of their inflorescence, and in thinning a number of them must be left in order to the formation of the seed. The male plants ripen long before the female plants, and should be pulled first, so as to promote the formation of a good crop of seed.

The stem of hemp is upright, from 5 to 8 feet high, and is strong and branching. Its valuable fibre makes the cordage of our ships. It is a native of the cooler parts of India, and is not cultivated there for its fibre, but for its intoxicating property. Lindley says that "it appears to owe its narcotic properties to the presence of a resin which is not found in Europe. This resin exudes, in India, from the leaves, slender branches, and flowers; when collected into masses it is the *churras*, or *cherris*, of Nepal. Its odour is fragrant and narcotic, its taste slightly warm, bitterish, and acrid." The hemp plant of India is a legumen of the order *Fabaceæ*, *Crotolaria juncea*, the sunhemp, which affords a coarse fibre, from which bags and low-priced canvas are largely prepared. "According to the observation of Vaucher of Geneva, the seeds of *Orabanche ramosa* will lie many years in the soil unless they come in contact with the roots of hemp, the plants upon which that species grows parasitically, when they immediately sprout. The manner in which the seeds of Orabanche attach themselves to the plants on which they grow has been observed by Schlauter. This writer states that they only seize seedlings, and are unable to attack roots of stronger growth."[1]

An oil is expressed from the seed of hemp, which is "employed with great advantage in the lamp, and in coarse painting. They give a paste made of it to hogs and horses, to fatten them. It enters into the composition of black soap, the use of which is very common in the manufacture of stuffs and felts; and it is also used for tanning nets,"[2] The proportion of oil from the seed varies from 14 to 25 per cent. The seed is used for feeding cage-birds, and all the finch tribe are remarkably fond of it.

The composition of hemp seed, according to Bucholz, is:—

Oil	19.1
Husk, &c.	38.3
Woody fibre and straw	5.0
Sugar, &c.	1.6
Mucilage	9.0
Soluble albumen (casein ?)	24.7
Fatty matter	1.6
Loss	0.7
	100.0

HOP CULTURE.

The hop is the most speculative of all the farm crops grown in the United Kingdom. Its produce varies from little more than 2 to 20, or perhaps even 25 cwt. per acre, worth from less than the cost of picking to upwards of £20 per cwt. Many fortunes have been made and lost in the growing of this crop, around which has gathered a halo of romance which hop-farmers delight to contemplate and talk of.

The hop requires a fine climate and good land. Its cultivation in this country is confined mainly to the English counties of Kent, Surrey, Sussex, Hampshire, Worcestershire, and Herefordshire, and usually occupies less than 70,000 acres.

One feature of the agriculture of the principal hop-growing districts is, that the hop may be almost said to monopolise the attention of the farmer, with the result that the other crops of the farm occasionally suffer.

Soil for Hops.—The soil for the hop plant should be deep and mellow, and if resting on a fissured rock, so much the better. An old meadow forms the best site for a hop-ground. In every case the ground should be dry—not subject to stagnant water, and, if not naturally dry, it should be made so by thorough drainage. To afford sufficient room for the roots of the plants, the drains should be not less than 4 feet deep, and the distances

[1] Lindley's *Veget. King.*, 265, 549, and 610.

[2] Wisset's *Treat. Hemp.*

between them from 15 to 35 feet, according to the tenacity of the subsoil.

Preparing Land.—Land which is about to be planted with hops is either trench-ploughed or trenched by hand in the autumn before planting. In the former practice the land is ploughed deeply with an ordinary plough, followed by a subsoiling apparatus, to break up the hard bottom as shown in figs. 46 and 47, pp. 119 and 120, vol. i. If this plan is not thought advisable or practicable, then the land is dug by hand labour to the depth of two spades. It is considered a good preparation to fold sheep on the land and feed them well before ploughing or digging; and at the time of ploughing or digging a heavy dressing of farmyard manure is given.

Rearing Hop Plants.—Hop plants are raised from cuttings taken from the "hills," or plant-centres, when these are being dressed early in spring. The cuttings are reared in a nursery until about the end of the autumn of the same year, by which time they have formed a strong root. These sets, or young plants, may be purchased from those who give special attention to their culture, and good judgment is required in selecting the kind best suited for each particular locality. Local experience is the best guide as to this, as well as in regard to many other points in farm practice. Attempts to raise hop plants from seed have not been successful, owing to the strong tendency of the plant to revert to its wild type.

Planting Hops.—The planting takes place either just before winter sets in or early in spring. The cuttings or shoots are planted in "hills," two or three to each "hill," the "hills" being from 5 feet 9 inches to 6 feet 6 inches apart each way.

There are two modes of arranging the plants in a hop-ground—one in squares, the other in quincunx. Of these two modes the quincunx is, in some respects, the preferable, because the plants, standing independently, are more exposed to sun and air; a greater number of plants are placed on the same extent of ground, in the ratio of 120 to 100; and the ground can be cleaned nearer the plants with the "nidget" or horse-hoe. In fig. 343 is shown the square method, in which the hills of hops are each surrounded, in a triangular form, by three poles. In cleaning the ground with the horse-hoe from *b* to *c*, one pole is closely passed at each hill on the right, and two poles are as closely passed on the left hand; and

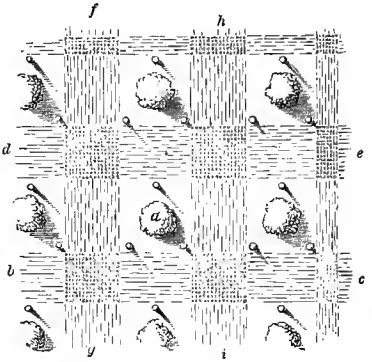


Fig. 343.—*Square mode of planting hops.*
a Square hill of hops with 3 poles.

the same happens in cleaning the ground from *d* to *e*. On cleaning the ground from *f* to *g* and *h* to *i*, one pole is passed closely on both hands at each hill. The lines in *b c*, *d e*, *f g*, and *h i*, represent the spaces of ground stirred by the horse-hoe. If will be observed that while one dark square piece of ground included between every four hills is stirred twice,

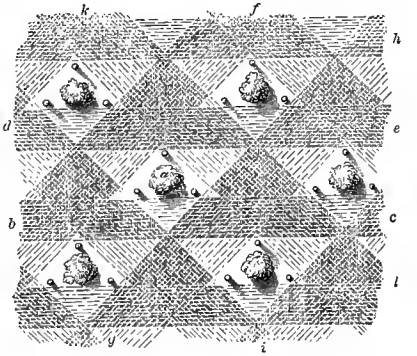


Fig. 344.—*Quincunx mode of planting hops.*

one square piece of ground surrounding each hill is left untouched by the hoe, and must be cleaned by manual labour at an enhanced cost, while the half of the ground is only once stirred.

In fig. 344 is shown the quincunx

method, in which each hop-hill is surrounded by three poles set in a triangular form, as in the square method. But here, in stirring the ground with the horse-hoe from *b* to *c*, and from *d* to *e* in one direction, and from *b* to *f*, and from *g* to *h* in a second direction, and from *d* to *i*, *k* to *l*, and *f* to *e* in a third direction, the ground is not only stirred close to each pole, which is as near the hop plant as any horse implement can approach, but the greatest proportion of it is twice, and some of it three times, stirred. Of the two modes, the quincunx saves manual labour in cleaning the smaller space of ground around each plant, but stirs the hoed ground oftener.

The maximum distance between the plants is regulated by the combination of the power of the soil and the nature of the variety of hops to produce the largest development of plant. The minimum distance is determined by the room required to keep the ground clean. In the maximum the distance should not exceed 7 feet, and for the minimum not less than 5½ feet. With 6½ feet as the distance, the number of hills in 1 acre is 1194 in the quincunx order, and 1031 in the square. The distances are set off by means of a measuring chain, and pins are stuck into the sites of the future plants.

The crop is not expected to give any produce the first year. In that season the ground between the hills may be utilised in growing potatoes, cabbages, or some such crop, though it is better not to do this, as the hop plants require a great quantity of manurial substance.

After Culture. — The vacant spaces between the "hills" must be well cultivated, and kept free from weeds, and heavily manured.

In the first spring a pole is placed in each "hill," and to this the young bines are tied, so as to be trained upwards. In the spring of the following year, when a crop is anticipated, the ground is again cultivated and manured, the hills dug with "spud" and hand-hoe; three poles stuck in at each hill, and any worthless suckers on the plants cut away. As the hop-bines grow up they are tied to these poles, which carry the bines high over a man's head. The "spud" is a three-pronged fork or "graip," with broad points.

The vacant ground between the hills must be frequently cultivated during the season, a sort of horse-hoe, or "nidget" as it is called in Kent, being used for this purpose. In the month of June the "hills" are earthed up by the spade.

The hop-land has to be thoroughly dug or ploughed every autumn or winter, the "spud" being used for this purpose.

When labour is scarce a small plough is used, but this has little or no effect in lessening the cost, as there is after all a good deal of the land around the "hills" and stacks of hop-poles stowed away for winter, which must be dug by manual labour.

Early in spring the adult hop plants are dressed as soon as the soil is sufficiently dry to be worked satisfactorily. The old bines and fibrous growth of the previous year are cut away, and some fine earth is thrown over the "hills." The poles, which had been removed at the time of "picking," are replaced around the "hills," and after this until picking attention is confined to the cultivating of the vacant ground—that is, unless fungoid or insect foes attack the plants and demand serious treatment.

Manuring. — Hops are greedy for manure. The annual produce of a hop-ground consisting of hops and bines is very considerable, and as the perennial nature of the plant does not permit it to be placed in the category of those plants of the farm which follow each other in any given rotation, it is necessary to manure the ground at least once, if not twice, every year. The first manuring after the crop may be given in autumn or spring; and if in spring, the time is before the digging of the ground commences. The best plan is to apply the manure twice a-year: in the spring, with farmyard manure and woollen rags, and during the summer with some such manure as guano, rape-cake dust, superphosphate of lime. Of farmyard dung, from 25 to 30 cubic yards should be given to an acre. Black mould is an excellent application about the crown of the roots, and from 80 to 100 single horse-loads may be put on an acre. The dung and mould may be carted on the ground before poling, and if applied afterwards,

is drawn on to the land between the rows of poles in long narrow carts called "dollys" in Kent. Of woollen rags from 12 to 20 cwt. per acre; woollen waste or shoddy from 20 to 30 cwt. per acre; and guano rape-cake dust, and superphosphate of lime, 6 or 7 cwt. per acre, are convenient applications, in June and July, generally dng in closely around the "hills," and sometimes spread over the surface, and hoed in with horse-hoes or "nidgets." Mustard-cake makes a good manure for the hop plant.

Details of Dressing. — After the manuring and digging in spring, the plant-centres or stocks are *dressed*, and cuttings taken from them. These are nice operations, and require an experienced hand to execute them, otherwise the success of the future will be rendered doubtful. Mr Rutley writes thus particularly on this subject—after stating that one boy or woman opens around the stock of the hill, with a small narrow hoe, a little below the crown of the hill—"one man follows with a pruning-knife and a small hand-hoe, with which he clears ont the earth on the crown of the hill between the sets or shoots of last year that were tied to the poles; and which, from having earth put on them the preceding summer, swell out to four or five times their original size, and form what we call sets or cuttings; and it is the cutting them off at the right part that should be particularly attended to, or great injury may be done. It is therefore necessary that the person cutting them should ascertain exactly where the crown of the hill is, that he may not cut them too low or too high; and the place where they shonld be cut off is between the crown of the hill and the first joint, for it is around the set close to the crown where the best aud most fruitful bine comes. If the set is pared off down too close to the stock or crown, it takes away the part from where that bine comes, as little buds are seen ready to shoot forth at the time of cutting, which, if cut off, the bines come weakly and few. On the other hand, if the set is cut off above the first joint, which sometimes will be the case if the man in cutting does not pay the attention to it he ought, the bines which come from that or any other joint higher up the set grow fast, but are coarse, hollow, or what we call pipy, and unproductive: all such should be discarded at the time of tying. Consequently the operation of cutting or dressing, on which the future well-doing of the plant so much depends, is not left so much to the judgment or skill of the operator as to his care and attention. Many planters have their hops dressed by the day, paying extra wages to persons in whom they can confide to do it with care. After all the old bine and rnnners, as the roots and small rootlets near the surface are called, are cut and trimmed off clean, some fine earth is pulled over the crown, and a circle made round with the hand-picker, to intimate where the hill is before the young shoots appear."

The dressing should be finished before the bines begin to show. Such of the sets as have two or more joints are selected to put into a nursery, or sold for that purpose. But the cuttings shonld be taken only from the most healthy bines.

Hop-poles.—Everything is now ready for the reception of the poles—for, the hop being a climbing plant, it is necessary that it be supplied with a pole sufficiently strong and long to support it effectively. The best poles are of ash, chestnut, larch, willow, oak cut in winter, birch, alder, beech, in the order enumerated.

Creasoting Poles. — Hop-poles are now universally treated with creasote at the ends, and this preparation makes them last about twice as long as before the practice was introdnced. The creasote, purchased at about 2½d. or 3d. per gallon, is poured into a tank into which the poles are set on end and kept there, sunk about 18 inches in the creasote for fnlly twelve hours. By this treatment the end of the pole which is stuck into the ground is rendered quite impervions to wet. There are three standard lengths of poles, 12, 14, and 16 feet, and the cost of poles for one acre of hops would run from £30 to as mnch as £70.

Poling. — In most cases there are three poles to each "hill," but often only two, and in other cases the one "hill" has three poles, and the next only two. The two or three poles are set arounnd each "hill" at equal distance

apart. A hop-pitcher makes a hole deep enough to give the end of the pole a firm hold of the ground, which should be about as many inches in depth as the pole is of feet in height. The pole is pushed down to the very bottom of the hole, and if it have any crook or set at the lower end, that is placed inwards, to be out of the way of the horses in "nidgetting" the ground; and the top should have a lean outwards, to give room to the bines to branch, and let in air and light, while the body of the pole should be as upright as possible, to give it the strongest position.

Tying up the Bines. — Whenever the bines shoot to a length to be fastened, they are tied to the poles. In some seasons when the bine comes very early the coarser bines are pulled out. Three of the best bines are selected to be tied to each pole, and the rest are cut away. Withered rushes are used for tying; and the tie is made with a slip-knot, so that the tying may give way as the bines enlarge in diameter. The tyings are done from near the ground up to 5 feet above it, and when above that height ladders are used, which stand independently upon the ground. The tying begins about the end of April. From 18 inches to 2 feet of the lower end of the bines may be stripped of their leaves, to allow air to get to the crown of the roots.

Substitutes for Poles.—There are other methods of poling hops, but these have not come into general use in this country. In Germany wire is extensively used as a substitute for poles, and this seems to be both economical and efficient.

Longevity of the Hop.—The power of some hop-grounds to produce a great crop year after year, when external circumstances are favourable, is extraordinary. Many grounds have borne crops for upwards of half a century, and some exceed in age an entire century. It must not be supposed from this, however, that any plant which had been planted at the formation of the ground remains alive such a length of time. Whenever a plant or an entire "hill" indicates symptoms of decay, it is removed, and another substituted; care being taken to plant the same kind of hop as that cultivated in the ground.

Insect and Fungoid Attacks.

The hop is unfortunately subject to serious injury from various insects and fungi. As to these attacks, see the chapter on the subject in this volume.

Harvesting Hops.

Picking.—The harvesting of hops is really autumn work, yet the brief description to be given of the process may be conveniently introduced here.

Hop-picking usually begins about the last days of August or the first week in September. The picking is a tedious process, demanding the employment of a great number of hands. As a rule the picking is done by bands of immigrants, men, women and children, who wander to the hop-growing districts from large towns and villages. The process generally extends over three weeks, and the immigrant pickers live in extemporised villages, in huts, hopper-houses, or tents provided for the purpose.

The process of picking is thus described by Mr Charles Whitehead, who has done much by his writing to improve the practice of hop culture [1]:—

"The pickers are divided into companies of eight or ten, each of which is under the charge of a ganger or 'binsman,' who pulls up the poles for the pickers with wooden levers having iron teeth, called 'dogs,' and holds the 'pokes,' or sacks, or 'sarpliers,' for the measurer when he comes round to measure the hops that have been picked. In most cases the bines are cut about 2 feet from the ground, and the poles are pulled by means of 'dogs,' or wooden levers with iron teeth, and carried to the pickers, who pick the hops from them into the bins or baskets. Occasionally when the hops are not quite ripe, or when the plants are weak, the poles are not pulled, but left standing. The bines are cut 4 or 5 feet high, and the bines with hops upon them are pushed up and over the poles with forked sticks, as bines cut high and kept to the poles in an upright position do not 'bleed' so much, or lose so much sap as when cut short and left lying on the ground. The hop-grounds are marked out into as many

[1] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 208.

portions or 'sets,' containing 100 hills, as there are companies, for which lots are drawn by each binsman, so that there may be no wrangling about good or bad sets. The hops are picked into bins — long light wooden frames with sacking bottoms. There is one of these for every two adult pickers. In Mid and West Kent and the Weald of Kent and Sussex, and in Worcestershire and Herefordshire, these bins are used. In East Kent large baskets are used for picking into, holding 15 to 20 bushels. In Hampshire and Surrey the hops are picked into baskets holding 7 bushels, which are emptied into long bags, called 'sarpliers,' holding 14 bushels, in which they are taken to the kilns. In Kent, Sussex, Worcestershire, and Herefordshire the hops are measured into pokes —sacks holding 10 bushels—in which they are taken to be dried. The measurer, who generally takes from six to eight companies, is accompanied by a boy, who enters the number of bushels picked into a book kept by each picker, and into a book retained by himself.

"The *price* of picking hops ranges from 1¼d. to 3d. per bushel. The average price is 2d. per bushel. Binsmen are paid from 2s. 4d. to 3s. per day. Measurers get from 4s. to 5s. per day. Driers, who work night and day, earn from £2, 10s. to £3, 15s. per week. Before picking commences, the planter generally fixes a price for picking. Sometimes it is not fixed until after a day or two, that it may be better ascertained how the hops come down."

Drying Hops.—Immediately on being picked, hops are artificially dried. They are dried in square or circular kilns, 16 or 18 feet square or in diameter, on haircloth, and heated by Welsh coal, coke, or charcoal. The kiln-floor is situate at 10 to 13 feet above the fire, and the height of the kiln is 18 or 20 feet above the kiln-floor, surmounted with a cap-cowl 7 or 8 feet in height and 3 or 4 feet diameter in the bottom, a free circulation of air being kept up through the fire and hops to the top of the kiln. The hops require to be rapidly dried to keep the pickers in operation. The kilns ought to take 1 bushel of green hops on 1 square foot of flooring, and be filled twice a-day, giving from 9 to 12 hours to each kiln-ful, so that from 200 to 250 bushels may be drying on one kiln at a time.

For two kilns of these dimensions, a cooling-room of 20 feet in width and 40 feet long is required. This should be on a level with the kiln-floor. And there should be another room of similar dimensions, under the cooling-room, for stowing and weighing the hops in the pockets.

Great caution is required to regulate the fires of the kilns. If too strong at first, when the hops are naturally moist, they will be drawn down to the haircloth and be much deteriorated in quality. The fire may be increased as the drying proceeds, and be pretty brisk near the last; but the heat should not much exceed that of 140° to 150° Fahr.

Hops shrink in bulk as they are drying. About 13 cwt. of coal, with a little charcoal, will dry one ton of hops.

Sulphur is also used in drying hops, from ¼ to 1 cwt. to 1 ton of hops. The object of using sulphur is to improve the colour of the hops. It is of importance to the seller to present his hops in the market with a light-coloured delicately greenish hue.

When taken from the kiln, the hops are laid in heaps on the cooling-floor, not only to cool, but to acquire a state of adhesiveness, which, though dry, causes them to lump together when squeezed in the hand, and yet not so much as to lose elasticity. This is an important point in preparing hops for packing, for if they are not sufficiently dry they will rot, and if too much dried they will become brittle, break into pieces, and be unsaleable.

The drying will cause a loss equal to about three-fourths of the weight in a green state—giving 1 lb. of prepared for 4 lb. of green hops.

Pocketing.—Hops are put into pockets in the stowing-room, through an opening in the floor of the drying-room, under which the pockets are suspended.

A *pocket* is 3 feet wide and 7½ feet long, consisting of 5 yards of cloth, weighing 5 lb., and contains 1 cwt. 2 qrs. and a few pounds gross weight of hops.

Hops cannot be too firmly packed in the pocket, and powerful screw-pressing machines are employed for the purpose. These presses, which are formed upon one principle, differing only in detail, are thus described by Mr Whitehead :—

"A wooden circular foot, just large enough to go into a pocket 3 feet in diameter, is fitted to a ratchet lever, which is worked up and down by handles. This is fixed immediately over the 'pocket hole' cut in the floor. The empty pocket is fastened to a movable frame or collar, so as to keep its mouth firm to the floor while it is being filled, suspended in mid-air. There usually are two posts set up below, into which two rods, connected with a wooden stand, run up to hold the pocket up and to keep it straight. In place of these guiding rods, some pressers have circular iron cases to surround the pocket and keep it from bulging. Pressers cost from £14 to £27." [1]

The pocket is neatly sewn up, leaving a lug, or ear, projecting from each side of the sewn mouth.

The produce is then ready for the market.

Stacking Poles.—When the bines are cleared of the hops, they are taken off the poles, which are then put up in small conical stacks at equal distances apart on the hop ground, with the sharped ends on the earth, having four equidistant divisions striding over the "hills." Each division of the stack should be bound round with three bines, deprived of their leaves and twisted into a rope, which binds the division close and compact, and prevents the poles being stolen, or makes a theft more easily detected. The small refuse poles are bound together, separating those which may be used for the young bines of the first year from those which may be burned into charcoal, or used as firewood.

The Hop Plant.

The hop, *Humulus lupulus*, belongs to the class and order *Diœcia Pentandria* of Linnæus, natural order *Urticaceæ*. Some plants have male flowers and others female flowers. It is generally believed that the hop was introduced into this country in 1524; but in *Notes and Queries* it is stated that in one of the covenants of a lease, granted in Kent in 1463-64, it is specified that the tenant shall receive "evry yere duryng the terme, an acre of wode competent and of the best fewell, exceptes Hope tymbere." [2]

Varieties of Hops.—No fewer than about 160 varieties of hops are said to be in culture throughout the world. In this country only a small number are in regular cultivation, the principal of these varieties being — Goldings, Bramlings, Grapes, Jones, Farnham Whitebines, Mathons, Cooper's Whites, Fuggles, and Colegates. The Golding is generally acknowledged as the best variety in this country, but for certain localities other sorts are more suitable.

The selection of the most suitable variety for a given locality and soil requires considerable experience and good judgment. Whichever kind is chosen, it is desirable either to have only one variety within one hop-ground, or the varieties separated in the same ground. Different varieties require to be pulled at different times. It is desirable, in choosing different varieties, to have them to ripen in succession, in order that the hops may not all be ready for picking at the same time.

Male and Female Hops.—The male and female being on separate plants, there has been a good deal of discussion as to the necessity or desirability of planting male plants so as to ensure fertilisation. It is contended by many that there should be at least one male plant on each acre of hops. But in practice no attention is paid to this. The male plants, Mr Whitehead says, are generally grubbed up, and the fertilisation of the female plants left to chance.

Ash of Hops.—The composition of the ash of hops was found by Nesbit to be as follows:—

	Golding Hop.	Yellow Grape Hop.
Potash . .	24.50	18.61
Lime . .	15.56	23.75
Magnesia . .	5.63	6.13
Phosphate of iron	7.26	6.79
Sulphuric acid .	5.27	4.16
Phosphoric acid .	9.54	5.26
Carbonic acid .	2.61	3.36
Chloride of sodium	7.05	3.18
Chloride of potassium	1.63	2.21
Manganese .	...	1.59
Silica . . .	20.95	24.96
	100.00	100.00
Percentage of ash	9.90	15.80

[1] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 214.

[2] 2d Series, ii. 276.

The quantity of mineral matter removed from the soil per acre by the different parts of the Golding hop plant is, according to Way and Ogston :—

	Flowers. lb.	Leaves. lb.	Bine. lb.	Whole crop. lb.
Silica	32.6	97.3	12.9	142.8
Phosphoric acid	29.5	40.6	15.1	85.2
Sulphuric acid	8.7	8.2	3.0	19.9
Carbonic acid	3.4	52.4	15.4	71.2
Lime	16.3	134.0	31.0	181.3
Magnesia	8.2	21.1	4.9	34.2
Peroxide of iron	1.1	0.8	1.0	2.9
Potash	54.0	57.0	22.9	133.9
Soda	...	...	...	...
Chloride of potassium	15.3	10.0	19.9	45.2
Chloride of sodium	1.3	13.6	3.4	18.3
Total	170.4	435.0	129.5	734.9

The hop plant is peculiar in the quantity of phosphoric acid required for all its different parts: in this respect it far exceeds any other plant which we have examined. It may not be without reason, therefore, that the value of land which is devoted to hops has been referred to the great prevalence on it of the phosphate of lime. The chemical history of the greensand district is such as to bear out this view.[1]

The composition of the ash of the flower of the hop, according to the analysis of Frederick Eggar, is :—

	Golding Hop.	Yellow Grape Hop.	Mean of analysis in 1 ton of hops. lb.
Potash	24.88	25.56	29 5
Lime	21.59	18.47	27 5
Magnesia	4.69	5.27	7 5
Peroxide of iron	1.75	1.41	2 4
Sulphuric acid	7.27	11.68	12 3
Phosphoric acid	14.47	17.58	25 2
Carbonic acid	2.17	4.54	...
Chloride of sodium	3.42	1.12	2 1
Chloride of potassium	...	4.34	4 6
Silica	19.71	9.99	25 0
	99.95	99.96	136 1
Percentage of ash, calculated dry	5.95	7.21[2]	

Spent Hops as Manure.—As spent hops are used for manure, the analysis of their ash, by Nesbit, may prove instructive :—

Potash	1.45
Lime	23.70
Magnesia	2.75
Phosphate of iron	2.50
Sulphuric acid	3.05
Phosphoric acid	4.10
Carbonic acid	9.00
Chloride of sodium	2.95
Chloride of potassium	0.70
Silica (soluble)	27.10
Sand and charcoal	21.80
	99.10
Percentage of ash	10.40

Cost of Hop-planting.—The planting of hops is very costly. Mr Charles Whitehead, writing in 1881, states that "the cost of raising one acre of hop-land, taking the average of all the hop districts in the kingdom, is £25," made up in the following manner :—

	£	s.	d.
Ploughing, subsoiling, and preparing the land	3	0	0
Manure, 30 loads at 5s. 6d.	8	5	0
Setting out and digging holes	1	5	0
2600 sets, at 3s.	3	18	0
Planting	0	8	0
Nidgetting and summer cultivation	2	0	0
Stakes or poles and setting	1	10	0
One year's rent, tithes, and taxes	4	14	0
Total cost of raising an acre of hop-land	£25	0	0[3]

Cost of Hop Cultivation.—Mr Whitehead gives the following as fairly representing the average cost per acre of cultivating an acre of hops in full plant :—

	£	s.	d.
Manures, including winter and summer dressing, carting, and spreading	7	0	0
Digging, or ploughing and digging	1	1	0
Dressing	0	6	0
Poling	0	14	0
Tying	0	13	0
Pulling bines, and earthing	0	4	0
Ladder tying	0	5	0
Keeping land clean round hills	0	7	0
Nidgetting and harrowing	1	15	0
Annual average supply of poles	4	15	0
Stripping, stacking pole, and making bines	0	12	0
All expenses of picking, drying, selling an average crop of 7 cwts. per acre	12	0	0
Rent, rates, tithe, taxes, repairs of oasthouse, interest	7	0	0
Total	£36	12	0[4]

[1] *Jour. Eng. Agric. Soc.*, xi. 515.
[2] *Ibid.*, ix. 145.
[3] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 218.
[4] *Ibid.*, 218.

Sulphuring and washing for blight would increase the cost in the former case from £1 to £3 per acre; and in the latter from £2 to £5 per acre.

Produce of Hops.—The produce of hops of course varies greatly with the seasons both as to quantity and quality. The average may be given at from 6½ to 7 cwt. per acre.

Price of Hops.—This varies remarkably, so great indeed as to invest the history of hop-growing with something of a romantic character. It has been as high as £30 per cwt. even as recently as 1882, but the importation of foreign hops, which rose from 24,662 cwt. in 1855 to 266,952 cwt. in 1885, has brought the price to a much lower level in recent years. The average has lately been frequently under £5 per cwt.

Hop-growing Risky. — The speculative, and therefore risky, character of hop-growing is well described by Mr Charles Whitehead, who says: "Hop-growing, even in the best districts, is a speculative business. There are men here and there who have made much money; but there are, on the other hand, very many who have lost much, and very many who are in prettty much the same position as they were twenty, or forty, or sixty years ago, when they began hop-growing, after having had the intense anxiety and worry which no one who has not had the experience of the changes and chances of this fickle crop can in any degree realise. No one who values peace of mind should cultivate hops, nor should any one who has not capital enough to 'stand the racket' of at least two bad seasons go into this business. Hop cultivation cannot be recommended to farmers who are trying to discover some culture likely to pay, or, at least, not to farmers in districts where hops have not before been tried, as besides the amount of capital that is requisite and the uncertainty of the crop, the demand for hops is limited strictly by the consumption of beer, and the competition of foreign countries is great. In seasons when hops are dear, substitutes, as quassia, for example, are used to a considerable extent, and the importations from Germany, France, Belgium, and the United States prevent prices from rising to famine point, as in the halcyon days when hops were worth £25 per cwt., and a small crop was hailed with satisfaction. The fluctuations in the acreage of hop-land show the uncertainties of this culture. Since 1878, for example, the acreage decreased from 71,789 acres to 64,943 acres, a decrease of 6846 acres. Since the duty was repealed in 1862 there have not been such sudden fluctuations in the acreage, as, for example, in the period between 1847 and 1849, when the acreage was reduced by 9530 acres; or between 1855 and 1857, when nearly 7000 were grubbed. These reductions, it need hardly be said, involve the loss of a great deal of capital, and are only made when it has become impossible by reason of bad seasons for planters to find money to work their hop-land properly."[1]

Since Mr Whitehead wrote the above in 1881, the fluctuations in the acreage of hop-land have been considerable. Then it amounted to 64,943 acres, and rose to 71,327 acres in 1885. Since that date it has rapidly decreased, and now (1889) stands at 57,750 acres, the lowest point since 1866.

SOWING TURNIPS.

Advantages of the Turnip Crop.—The turnip crop plays a great part in British agriculture. For the light land in the northern districts of the British Isles, where the climate is too cold for the sugar-beet or even the mangel crop, the turnip crop is of primary importance. It enables the farmer to clean and fallow his land, and at the same time to grow an immense quantity of nutritious cattle food, even from poor light soil. It has been said that the greatest improvement in arable land farm-

[1] *Jour. Bath and West of Eng. Agric. Soc.*, 1881, 220.

ing during the last hundred years is due to the introduction of the turnip crop into the rotation; thus providing, as it did, a cleaning and fallowing crop, and obviating any necessity for a bare fallow on light soils, and enabling the farmer, during the winter months, to keep a number and quality of cattle formerly impossible.

The turnip crop has, to a large extent, given to Scottish agriculture the eminence it has attained, and it has made the eastern half of Great Britain the greatest cattle-feeding district in the world. If properly managed, the crop is a moderately reliable and valuable one on the lightest and shallowest of soils; and although in some cases it has been too often repeated on the same land, whereby inferior crops and destructive disease have been produced, its introduction has been of immense advantage, and its place in the rotation cannot be filled so well by any substitute which has as yet been tried.

On stiff clay soils its cultivation is not of so much advantage. The cost of reducing these to a proper tilth for the seed is great, and if the weather is either too wet or too dry, the crop is precarious and uncertain. Then clay land is liable to be injured either by carting the roots off the land or by the treading of sheep in consuming them upon it.

Unlike the potato crop, the turnip crop is usually consumed on the farm, and the unappropriated matter returned to the soil. In properly constructed farmeries there should, therefore, by the growth and consumption of roots, be comparatively little waste of manurial elements, and consequently little exhaustion of the land.

Turnip-growing may be Overdone.—The serious injury which the turnip crop has so frequently in recent years sustained from insect and fungoid plagues, together with the heavy costs involved in its cultivation, have somewhat weakened the hold which it obtained on the affections of the British farmer. The decline in the price of grain has also tended, indirectly, to lessen the area under turnips. It has been contended, with a good show of reason, that the unfavourable experience with the crop has been in a large measure due to an attempt to grow roots upon the same land too frequently—that is, with too short an interval between the successive crops of roots. In speaking of the fungoid attacks upon roots, further reference will be made to this point, of the too frequent recurrence of the crop on the same land. Here it will suffice to say that it has been clearly proved that the growing of roots, like most other things, can be easily overdone, and that the results of an indiscretion with this tendency may be almost disastrous.

With this qualification, there are few who would not indorse what is said above as to the advantages of the turnip crop and the part it has played in building up the fabric of British agriculture.

Varieties of Turnips in Use.—In vol. i. pp. 160-169, some information will be found as to the varieties of turnips. The varieties now in use are very numerous. Of the Swedish turnip (*Brassica campestris, rutabaga*) there are over 20 field varieties, more or less widely cultivated; and of the common turnip (*Brassica rapa*) and hybrids there are more than 50 varieties in cultivation.

Swedes.—The Swedish turnip has a blue-green smooth foliage. It is a comparatively slow-growing plant, and therefore requires to be sown earlier than the common turnip. It requires for its successful growth, and will resist without injury, a greater degree of heat; is less watery; of harder texture; will stand several degrees of greater cold without injury; and will keep longer than the common turnip. The bulbs of some of the varieties are green-topped; some are purple or bronze-topped. The purple-topped varieties are usually more or less tankard in shape, and thus stand farther out of the soil. In consequence, they are more apt to be injured by severe frosts, and should be lifted and stored early. From their habit of growing well out of the ground, they are thought to be better suited for shallow soils than the green-topped varieties, the general shape of which is globular. The bulbs of the latter are more deeply seated in the ground, and are thus better protected from winter frosts.

Common Turnips.—The *Brassica rapa*, rough-leaved summer rape, or turnip, has rough foliage of a more decided

green colour. The yellow-bottomed varieties are looked upon as a cross between the swede and the white turnip. They grow more rapidly than the *Brassica* swede, and come to maturity sooner. They may therefore be sown successfully much later. They will grow on a poorer soil, and in a colder climate. The bulbs contain less solid matter, are more easily injured by hard frosts; they should therefore be used or pitted sooner than is necessary for swedes.

The varieties called *hybrid* are a cross between yellows and white varieties, and are usually soft in flesh, tankard in shape, and ill adapted for resisting hard frosts. The white-bottomed varieties are even more rapid in growth, more soft in texture, more easily injured, and more watery than the yellow-bottomed varieties.

Some varieties of the yellow-fleshed are green, some are purple-topped. The white-fleshed varieties are white, green, grey, purple, or red-topped. The latter are now but little cultivated, while the area occupied by the Swedish varieties is steadily increasing.

Produce of different Varieties.—Experiments, purposely conducted to test the point, and general experience in turnip culture, have shown clearly that there is a very wide range in the productive powers, not only of the various kinds of roots, but also of each individual variety, propagated and grown under different conditions. In the midland and southern counties of England the crop of swedes generally runs from 12 to 18 tons per acre; in Scotland, Ireland, and north of England, from 18 to 30 tons. Common turnips may give from 1 to 4 or 5 tons more per acre. Often, indeed, the extremes are still greater.

Much of course depends upon soil and climatic conditions, which are beyond the control of the farmer, and still more perhaps upon the system of culture, which is almost entirely within his direction; yet it is unquestionable that, by selecting sorts which have been distinguished for abundant production upon the different classes of soils, the yield of the crop may be sensibly increased. In regard to the feeding and keeping properties of roots, the same remark holds good. With turnips, as with all farm plants and animals, the selection of the sorts best adapted for the surrounding conditions and the purposes in view, is a point which demands, and will repay, the most careful attention from the farmer. Indeed it is a point which the farmer who would be successful cannot afford to overlook or disregard.

Climatic Influences on Turnips.—The turnip has a moderate range of temperature. A summer isotherm of about 56°, with a moderately moist atmosphere, is the most favourable. Before getting into the rough-leaf stage, it is easily adversely affected with night frosts. These, with hot scorching days, such as are frequently experienced in the end of May and first half of June, are very inimical to the young turnip in its cotyledon stage, and often cause its destruction, and necessitate resowing.

Insect Attacks.—This condition is generally aggravated by the attacks of insects, such as the turnip-beetle (*Haltica*) and several kinds of weevils (*Curculio*), that puncture and nibble at the seed-leaves, which in dry weather tends to kill the plant from bleeding or drying up. At this stage insects seldom do much harm if the weather is damp, and the nights free from frosts.

Distribution of the Turnip.—The turnip is therefore a plant whose constitution is eminently suited to the damp and comparatively cold climate of the British Isles. The crop indeed reaches its most certain and highest development in the northern parts of the islands. The cool climate of Caithness, Orkney, and even Shetland favours its bulb growth. In the Hebrides it grows well, the damp air causing increased luxuriance of top.

In the south of England the turnip is often a failure in dry seasons. The hot dry winds occasionally experienced there are liable to kill the plants in the early stages, and to cause stunting, and sometimes mildew, if the growth is farther advanced. There, in some seasons the plant has a struggle for days and weeks with dry warm winds and a parched soil, and makes little progress until the shorter days and cool nights of autumn set in.

The turnip thrives in a temperature too cold for the profitable cultivation of cabbage, kohl-rabi, or mangels. These

in the British Islands do best in moderately dry warm seasons. Among grain crops, the oat luxuriates in a climate similar to what is required for the growth of turnips, and wherever heavy, well-filled oats can be grown, there the cultivation of the turnip will succeed.

Turnips in Foreign Countries.—The crop is cultivated in large breadth only in the British Isles. On the continent of Europe, if we except some parts of Denmark, the breadth of it is quite insignificant. In southern Europe maize is the chief forage crop. In middle and northern Europe the sugar-beet and potato take the place of the turnip in stock-feeding. In the older settled parts of Canada turnips are grown to some extent. The soils of Quebec and Ontario are generally highly suitable, but the summer is rather dry and warm for the turnip, and in consequence the average weight is only about two-thirds that of the British Isles, while the severe winter compels early storing in cellars. In New Zealand turnips are grown for sheep-feeding, and to save labour the seed is usually sown broadcast, and allowed to grow without thinning. In Victoria, Australia, the cost of labour has operated against the cultivation of turnips. The summer is too dry, but very promising and heavy crops, up to forty tons per acre, have been grown during the winter months.

Soils for Turnips.—The soils most suitable for turnip cultivation are those of a light friable description. The fine state of division to which these can be readily reduced favours the germination of the small seeds. On such soils cultivation is easy, and they also suit the habits of the plant, which spreads its roots like a network into every part of the soil.

Alluvial and sandy soils are the best for the turnip plant. Next come the lighter soils formed from trap or volcanic rocks, and the lighter soils resting on Silurian, Cambrian, Devonian, granitic, and New Red Sandstone rocks.

Clay Soils Unsuitable for Turnips.—The soils least suitable are the clays, from whatever derived. The London, Oxford, and Kimmeridge clays being especially stiff, are not well suited for turnip cultivation, partly from the great difficulty in securing a braird among the rough particles in dry seasons, from the hardness of such soils preventing the free spreading of the roots, and from the absorbed and retained water injuring the roots in wet seasons. On the stiffer clays, which occupy a large area in the southern part of England, the cultivation of the crop is so precarious that it cannot be profitable in the average of seasons, although good crops are occasionally grown. Were it not that the working of the land for the crop acts upon the soil similarly to a bare fallow, its cultivation on these soils would not be attempted to any considerable extent.

TILLAGE OF TURNIP LAND.

Variety of Systems.—The system of tilling land so as to prepare it for the turnip crop necessarily varies greatly upon different classes of soils, and in the different parts of the country. The condition of the land as to foulness or freedom from weeds has likewise to be considered in deciding upon the system of tillage likely to be most effective and economical.

It has also to be remembered that in many farming operations there are variations in local customs, for which there is no apparent or sufficient explanation beyond the simple influence of long-continued usage. In regard to most branches of farm-work, it is assuredly true that there are several ways of doing the same thing,—several methods by which the same piece of work may be accomplished, and this, too, with almost equal efficiency, and with little difference in outlay.

That teaching which would seek to inculcate the idea that any one way is *the* right way and the *best* way, and all other methods wrong and inferior, is essentially narrow and unsafe, arising most likely from limited experience or a dogmatic spirit—or from both; for there is a close kinship between dogmatism and limited knowledge. The more one sees of the detail-work of farming in the various divisions of our own country and in foreign lands, the less inclined one is to dogmatise, the more indeed is one impressed with the almost infinite variety of methods and practices which farmers

may, with prudence and good results, pursue in the prosecution of their calling.

The introduction of these remarks at this particular point has been suggested by the fact that in his observations as to the methods of root culture in nearly every corner of the British Isles, and in foreign countries as well, the editor of this work has noted with special interest the almost endless variety in the details of practice. In perusing the remarks which follow as to the system of preparing turnip land, and in contrasting the practices described and recommended with different practices which may prevail in certain localities, it should therefore be borne in mind that it is not presumed by us that the methods described here are the only methods worthy of description and commendation. Indeed we will go further, and suggest that any farmer who has been moderately successful with methods different from those described here should think well before introducing a change, doing so at first only to a small extent, and in an experimental way. To describe all the good systems of root culture is out of the question. We, however, set forth the details of certain methods which we know to be pursued with success in different parts of the country.

Soil, Climate, and System of Tillage.—The character and condition of the soil are of course the main considerations in determining the system of tillage. Stiff clay land requires very different treatment from light friable soil. The former must not be touched in wet weather, or while it is in a very wet condition. The latter is much less liable to injury from unseasonable working.

The climate is also answerable for variations in systems of tillage. The comparatively mild open winter of the southern and lower-lying parts favours autumn and winter tillage. In the higher-lying and colder districts, with their severer winter, much of the tillage work must be delayed till spring.

Prevailing System. — The system which prevails most largely in the principal turnip-growing district of this country, is to plough the land with a strong furrow in the autumn or winter, allow it to lie in this condition under the disintegrating influences of winter, and in spring clear it of weeds and reduce it to the desired condition for the reception of the manure and the seed. Unless the land happen to be exceptionally foul, or is of a strong clayey nature — in which cases other methods to be explained presently may be adopted—this system of autumn or winter ploughing and spring cleaning and manuring answers admirably for the turnip crop.

Normal Conditions.

In the first place, we will describe the process of preparing land for turnips, under what may for convenience be called *average or normal conditions.* By this term is meant land well, or at least moderately well, suited for turnips — heavy clays excluded; in average condition as to weeds, fertility, and drainage, and with average weather.

Exceptional circumstances will receive treatment subsequently.

Autumn and Winter Ploughing.—Turnips almost invariably follow a grain crop. As soon as practicable after the completion of the grain harvest, the stubble land intended for roots next year is—unless very foul—ploughed with a deep strong furrow, varying in depth according to the character and depth of the total surface-soil from perhaps 10 to 14 inches—rarely over 12 inches. In deep ploughing care has to be taken not to bring to the surface more than a very small quantity (if any) of the subsoil at one time. Many subsoils contain matter which is positively injurious to vegetation, and which, if mixed freely with the surface-soil, may for a considerable time have a deleterious influence on the crops. If the land be strong loam, it may be advisable to yoke three horses in the plough. When the land is very steep, and it is desired to run the furrow up and down the incline, the plan of going up-hill empty and taking a strong furrow down-hill is often resorted to. With this method no feerings are required after the first side furrow, as all the ploughs follow each other at convenient intervals in the one furrow.

A good deal of time, however, is unavoidably wasted by this plan, and farmers generally contrive to get a furrow each way by running the plough so to avoid the direct line of the incline. For ploughing with a strong furrow in

steep land the one way, ploughs described and illustrated in vol. i., pp. 117, 118, are very useful. With the one-way plough the furrow can always be thrown downhill, which of course lightens draught greatly.

In this strong furrow the land lies over winter, deriving much benefit from the frost and snow to which it is thus freely exposed.

Spring Tillage.—In average seasons the land intended for turnips, which has been ploughed in autumn or winter as just described, may probably not be touched again until the sowing of the grain crops has been completed. The spring working of the turnip land is usually begun in April, but the greater portion of it will most likely have to be gone through in May, some of it perhaps even later.

The extent and nature of the spring tillage will depend upon the character and condition of the land and the state of the weather. For even in what may still be called normal or average conditions, there are many variations which demand the careful consideration of the farmer.

Ploughing or Grubbing. — Most likely one spring ploughing will be sufficient, this time with a moderate furrow, perhaps from 6 to 9 inches deep. Many farmers now prefer to stir the land with some kind of strong iron-toothed implement of the grubber kind; or it may be a half-plough, half-grubber,—an implement having a plough-like sole, and iron spurs instead of a mould-board.

Whether it is advisable to plough the land, or only to drag it with a grubber or cultivator, will depend upon the kind of soil and the weather at the time. If the subsoil is very hard, the plough will pierce and loosen it more effectively than the grubber or cultivator. If the season is wet the plough is preferable, as much less injury is inflicted by the treading of the horses in ploughing, unless the grubbing is done by steam-power, which is very effective, if not done too deeply.

The cultivator gets over the land much more quickly than the plough. But if the soil is stiff or full of weeds, a second turn after harrowing and gathering will be necessary. By the use of the cultivator the fine surface-mould produced by the winter frosts will be kept nearer the surface, and will make the germination of the turnip seed more certain. In stiff soils fewer of the large clods will be brought to the surface; in dry weather less evaporation from the surface will take place, and the success of the crop will be more assured.

Diggers and Cultivators.—Some of the implements intermediate between the ordinary cultivator and grubber and plough perform excellent work in the preparation of turnip land. The digger brought out by Messrs Barclay & Sellar, and manufactured by Messrs George Sellar & Son, Huntly, represented in fig. 345, is a good sample of these implements. This digger has coulters and shares just like a plough. The breast or mould-board, however, is totally different, inasmuch as it is made in two halves. The upper half turns the furrow-slice similarly to the plough. The lower half, being turned at an angle to the passage of the furrow, cuts off the under surface as it passes over, and allows it to fall loosely into the bottom. The effects produced are thus a combination of the plough and cultivator.

This digger may be used for other purposes besides preparing turnip land in spring.

Used on stubble land it pulverises the soil to a good depth, and turns only the upper few inches, thus exposing the roots of weeds which lie near the surface to the winter's frost, and leaving the soil thoroughly broken up. Amongst land after turnips it also does good work. While pulverising the soil it does not turn it over, and expose the dung, as is often done by the common plough.

Further reference to the use of the grubber or cultivator will be found in page 203 of this volume—vol. ii.—where illustrations will be found of Clay's cultivators.

Pulverising Ploughs.—By the attachment of revolving prongs, ploughs are made which, at the one operation, plough the land and pulverise it, throwing most of the weeds on to the surface. An excellent implement of this kind is that represented in fig. 346, made by T. Corbett, Shrewsbury.

Disadvantages of Grubbing.—The

drawbacks to grubbing are the putting down of the weeds by the hoofs of the horses, which press some of them beyond the grasp of the harrows following; and the hardening of the subsoil due to the pressure of the horses' feet. Both these are points of some importance, yet grubbing or cultivating is on the increase.

Harrowing Turnip Land.—Whether ploughed or stirred, the land must be afterwards harrowed, the weeds picked off, and the large stones, if any, gathered. If the weather permit, harrowing and rolling must be continued until the clods are reduced, and a fine mould formed.

Removing Weeds.—The harrowing brings the weeds loosely to the surface. Chain-harrows are frequently used to collect the weeds into heaps, and so are horse-rakes, the work being concluded by hand-rakes and forks, or graips. Hand-picking is preferred by many farmers, and is of course the most thorough system. The weeds may be burned in heaps on the field and the ashes scattered

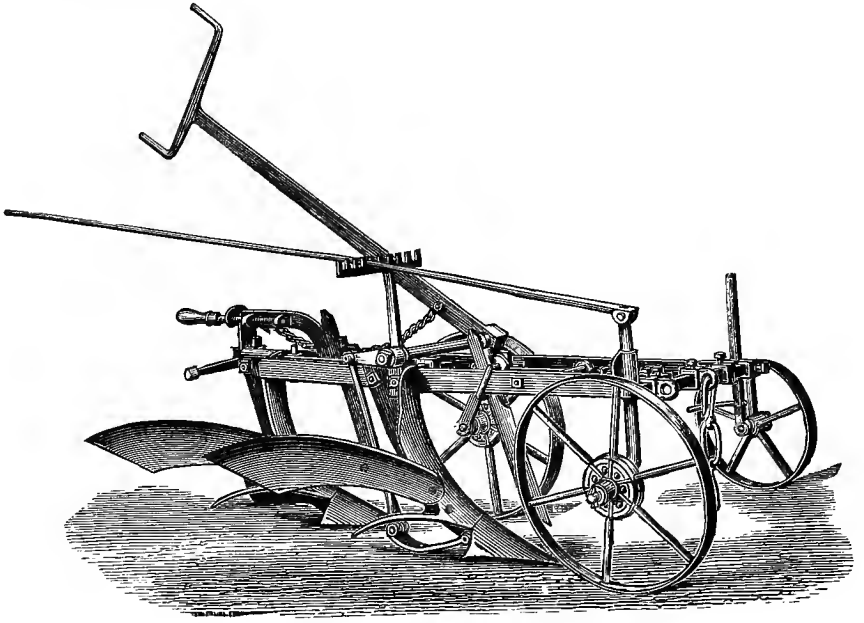


Fig. 345.—*Barclay and Sellar's patent digger or cultivator.*

around, or carted to some convenient corner to be united with lime to form a compost-heap. In the latter case care must be taken not to spread the compost on the land until the vegetable matter in it has been thoroughly decomposed.

Exceptional Conditions.

In soils well suited to turnips, and kept in good heart and condition as to cleanliness, the foregoing process of tilling and cleaning will most likely be sufficient to prepare the land for the sowing or laying down of turnips, as it is often termed.

But there are many circumstances which render deviations from the prevailing system necessary or advisable. For instance, stiff clayey land, land which is excessively foul, and land unusually free from weeds, all receive peculiar methods of treatment. Again, the land may be both stiff and foul, and in this case still another plan will be adopted. The questions as to whether the roots are to be sown in drills or on the flat, and at what time the farmyard dung is to be applied—whether in the autumn or winter, on the flat in spring, or in drills at sowing-time—are also responsible for variations in the preparatory work.

Preparing Foul Clay Land.

This is often a serious undertaking. No progress can be made with it in wet weather. Indeed, any attempt to cultivate or clean clay land when it is in a wet condition must inevitably result in failure. Far better let men and horses remain idle than allow them to work stiff clayey land unseasonably. In this condition the more it is worked the greater is the injury inflicted.

When therefore the farmer has before him the unenviable task of having to clean a stiff clay land which is in very foul condition he must watch the weather carefully and seize every suitable day for the purpose.

Autumn Cleaning.—For cleaning land of this kind the autumn is the best time—that is, if the weather should be favourable. Begin the work as soon as the grain crops are secured. The first operation will either be the cultivating (or grubbing) or the ploughing of the land with a shallow furrow,—a furrow just deep enough to turn over, but *not to bury*, the weeds. The depth of the first furrow is indeed regulated mainly by the character of the weeds, whether they are deep-rooted, creeping, or surface weeds. Some of the surface-weeds may be killed by being buried with a deep furrow; but couch-grass, docks, thistle, knap-weed, and other well-known troublesome weeds, require more drastic treatment. Grubbing or dragging and harrowing follow ploughing, and if necessary to break

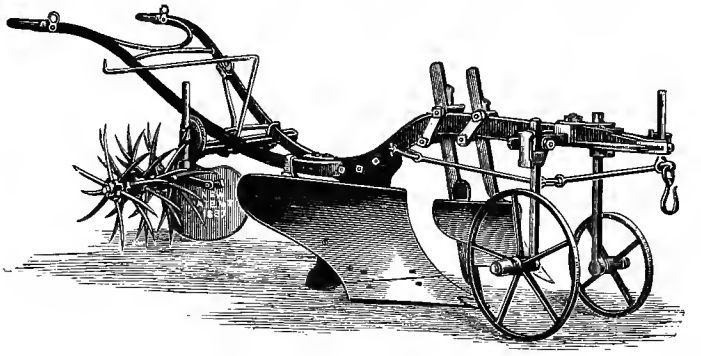


Fig. 346.—*Digging and pulverising plough.*

clods holding weeds, the land is then rolled, again harrowed, and the weeds collected and burned or carted away.

A Second Crop of Weeds.—An examination of the land may reveal the fact that it is still far from clean. In this case the whole process should, if the weather permit, be at once again gone over. The ploughing may perhaps be omitted. The grubber or cultivator, followed by the harrows, will take the remaining weeds to the surface, and this time, in particular, it will be advisable to hand-pick the weeds, so as to ensure that all the little particles of couch-grass roots may be removed.

Do not Break Weeds.—Excessive tillage is liable to break these weed-roots into small pieces, each of which, if left, will form a centre of filth. It is therefore important to have the weeds brought to the surface with as little knocking about as possible.

Cross-cultivation.—The subsequent ploughing and grubbing are usually given at right angles to or in a slightly different line from the preceding. The object of this cross-cultivation is of course to ensure that all portions of the soil may be stirred.

Steam-power for Cleaning Clay Land.—For the cultivating and cleaning of strong land steam-power is very suitable. The steam-cultivators go over the ground quickly, and they can be as easily regulated as to depth as implements for horse-labour.

Half-ploughing.—Land which is *excessively foul* is sometimes cleaned by another process,—a piecemeal method

known as break-furrowing, raftering, or half-ploughing. Only half the surface is at once disturbed, each furrow being thrown on to its own breadth of ploughed land. Harrowing and weed-collecting follow, and this fleece of weeds being removed, the strips of the land formerly undisturbed are then turned over by the plough, harrowing and weed-collecting completing the process. This is a tedious and costly process, which is not often adopted, and need not be resorted to except in such rare cases as where the land is so excessively foul that the entire mass of weeds in it could not be conveniently dealt with at one time.

This system is more frequently adopted for the purpose of killing surface-weeds. In this case the land lies over winter in the ridged-up appearance which the half-ploughing gives to it.

Autumn Dunging and Ploughing.—Assuming that the weather has been sufficiently dry and free from frost to enable the farmer to complete in autumn and early winter the cleaning processes described above, the next step—with strong land intended for roots—will perhaps be to spread its allowance of farmyard dung and plough in this with a shallow furrow. This is the usual practice, and by far the best plan in stiff land of this kind, where the turnips are to be sown on the flat, and where there is a sufficient supply of dung ready in time for application before the last ploughing in autumn or early winter. The advantages of the autumn instead of the spring dunging of heavy land will be mentioned in dealing with the manuring of turnips. If the dung is not to be applied at this time, the land is turned over in a strong furrow before the rigours of winter fairly set in.

Spring Tillage of Strong Land.—The spring tillage of stiff clays intended for roots has to be carried out with the utmost care and caution. Clay is stubborn material, in the working of which the farmer, who has not before had practical experience of it, is liable to unwittingly commit errors, which may seem trifling at the time, but which may result in serious injury to the crop.

If the land has been cleaned and dunged in the autumn, the spring work is thereby greatly simplified. Lying over winter in a strong furrow the land becomes pulverised and more easily prepared for the seed. In southern parts, where the winters are open, the spring tillage of this land is begun as early as possible—as early as January or February if the weather is sufficiently dry. It is then cross-ploughed at least once. Often, indeed, strong land is ploughed two or three times in spring, in the attempt to reduce it to that fine tilth which is so advantageous to the root-crop.

Grubbing or Cultivating in Spring.—Grubbing or cultivating is preferable to repeated ploughing in spring, for while the former leaves the finely pulverised soil on the surface, the plough turns this underneath.

By repeated harrowing, rolling, and grubbing or dragging, the rough strong land is reduced as finely as possible, and is thus prepared for the reception of the seed.

Preparing Clean Land.

When the land intended for turnips is in a cleanly condition, the preparatory tillage operations may be considerably lessened. As early as possible in the autumn or winter, the land, whether light or strong, is ploughed with a deep furrow or cultivated with a rank grubber. On strong clay land the dung—as much of it as is then made—is spread on the stubble just before ploughing.

In spring, strong clean land will require similar treatment to that just described in speaking of the preparation of foul clay land, which had been cleaned in the autumn.

Spring Tillage of Light Clean Land.—But in the case of light land free from weeds, very little spring tillage may suffice. Indeed, such land may be allowed to lie in the winter furrow till the work of grain-sowing is finished. It may then receive a strip of the harrows across the winter furrow, be turned over once with the plough, or stirred by the grubber or cultivator, and again harrowed two or three times. In many cases this will be found sufficient; but if the tilth is not reduced as finely as desired, another turn of the grubber or cultivator and harrows may be prescribed, and with this the preparation will be completed.

Overworking Injurious.—Not un-

frequently injury is inflicted upon the turnip crop by the overworking of the land in spring. Turnips delight in a fine moist soil. The finer the soil is the better, but it must also be damp. In preparing turnip land, therefore, the farmer must strive not only to break down the soil but also keep in the moisture. This, as will be at once understood, is not so easy to accomplish. Repeated ploughing and opening up the land, late in spring and early in summer, encourages the escape of moisture. It is thus important that in dry districts the deep turning and stirring of the land should be done in autumn, winter, and early in spring, so that when the dry season has set in, shallow stirring and surface-scratching may be sufficient to provide the desired tilth.

The dissipation of moisture by spring tillage may be to some extent lessened by immediately following the ploughing or grubbing by harrowing and rolling.

Even in moderately moist climates this matter is deserving of more attention than farmers, as a rule, bestow upon it. Indeed it may be described as one of the cardinal points in successful turnip culture. The importance of retaining moist soil around the young turnip plant is perhaps the consideration which has been most powerful in maintaining the system of growing turnips on the flat in England.

Forking out Weeds.—A practice much pursued in England, with land not so foul as to require a special course of tillage to clean, is to send several workers over the stubbles in the autumn with graips or forks to dig out couch and other visible weeds. This is a good plan, likely to save after-labour in removing weeds.

It is the habit, indeed, of some particularly careful farmers, to send two or three labourers over the entire farm in this way, forking out any weeds to be seen, and giving special attention to headridges and sides of fences, which often form perfect nurseries for weeds.

Turnips on very Strong Clays.—In some cases in England, on very strong clays, which are by nature ill adapted for turnip culture, crops of swedes, which would delight the heart of any farmer, are occasionally grown. The main secret of success, in these instances, has nearly always been the studied and careful preparation of the land. Such deep tillage and cleaning as the land receives are done in dry weather in autumn, when the dung is also put in. Then in some cases which we have known to be successful in an eminent degree, no further stirring of any kind is given to the soil till sowing-time, when, after a turn of the harrows, the seed is sown in rows on the flat.

This plan, of course, would not succeed in land containing many weeds; but on some of the strongest clays in England we have seen it carried out with the most gratifying results—upon land so strongly adhesive that it would sometimes exhibit in spring with little effacement the footprints made upon it by labourers five months before.

The chief difficulty in turnip culture, on strong clay land in a dry climate, is to obtain a strong regular plant. This is most effectually promoted by retaining the winter moisture in the soil. And the best method of conserving the moisture is to clean, dung, and plough the land in autumn, and stir it as slightly as possible after the advent of warm weather in the following season.

Still, when the farmer has done his very best, turnip-growing upon very strong clayey land will often fail. And while it is interesting and may be useful to record these instances of exceptional success, one cannot with confidence recommend the extensive culture of turnips upon such land.

Flat and Drill Systems of Sowing.

For some time at the outset turnips were without exception sown broadcast on the flat surface of the land. At one time, indeed, that was the universal custom with all farm crops.

Introduction of Drill Sowing.—For the introduction of that most serviceable system of drill sowing, we are indebted to Jethro Tull, whose writings, during the first generation of the eighteenth century, did much to promote the improvement of farm practice. In his book on 'Horse-hoeing Husbandry,' published in 1731, he advocated the system of drill-sowing wheat in narrow ridges. The success of the method attracted much attention, and it was soon after tried for other crops.

For turnips it was found specially suitable, and as early as 1745 the drilling of turnips was practised in Dumfriesshire by Mr Craig of Abbeyland. The system rapidly won many converts, and soon after the middle of the eighteenth century, turnip culture in drills or rows was being pursued successfully in various parts of the country, notably, besides Dumfriesshire, in Cumberland, Northumberland, Roxburgh, Berwick, and Norfolk. Indeed, to the last-named county, still noted for turnip culture, an improved system of turnip cultivation was as early as 1730 introduced from the Netherlands by Charles, Viscount Townshend of Rainham.

Turnips in Raised Drills.—In Scotland, Ireland, and the north of England, turnips are now universally grown in raised drills. This method, it is said, dates from about 1760, when it was begun by Mr Dawson of Harperton, Kelso. For districts with a moist or moderately moist climate, it has long ago proved itself to be superior to all other methods of root culture.

Disadvantage of Raised Drills.—The one drawback to raised drills is that throwing up the land in this form encourages evaporation, and thus intensifies the effects of drought. Mainly for this reason, the system of sowing in rows on the flat is preferred in the greater part of England.

Advantages of Raised Drills.—The system of raised drills possesses several advantages of the highest importance. In the first place, the gathering of the finely pulverised soil together in the raised drill, gives the roots the benefit of a deeper and freer soil than they would obtain on the same soil in the flat system. The stores of plant-food in the surface-soil, and the manure applied at the time, are brought into closer proximity to the young plants, whose growth in the early and most critical stages is thus effectually stimulated. The thinning and hand-hoeing of the crop are more easily and expeditiously accomplished in the raised drill than on the level surface, while the subsequent hand-hoeing and horse-hoeing, or drill harrowing, bring back the land to a nearly level condition by the time the crop is throwing out its spreading root-fibres.

Width of Drills.—This varies from 25 to 30 inches, the most general width being 27 inches. In narrow drills there is difficulty in covering rank dung thoroughly, and there is less facility for horse-hoeing. On the other hand, the yield of the crop per acre will be lessened by having the drills much wider than about 27 inches.

Drill-plough.—The raised drills are now most generally made by the drill-plough, the construction of which is well shown in fig. 347, in an improved

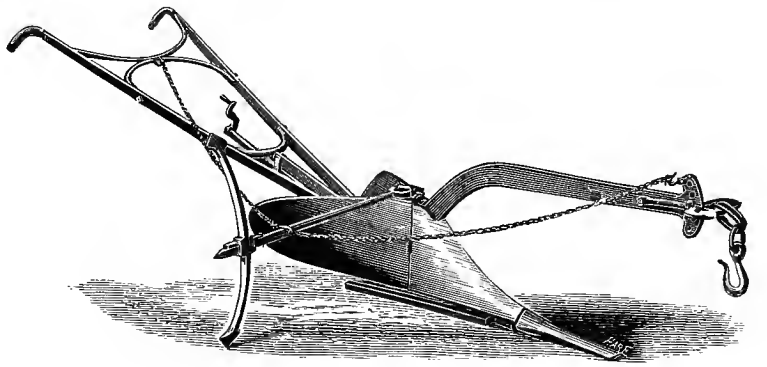


Fig. 347.—*Drill-plough.*

drill-plough made by Newlands & Son, Linlithgow. The breast and mould-boards of this, as of all other improved drill-ploughs, are formed so as to throw up the soil loosely rather than to squeeze it together, as would be done by a wedge-shaped plough. The width of the drill can be easily regulated by the screw

shown between the shafts. The "marker" is adjusted to the corresponding width, and with these improved ploughs a skilful ploughman makes drills that are pleasing to the eye of a tasteful farmer —straight in line, and uniform in depth and width.

The *depth* of the drill must be sufficient to thoroughly cover the dung. Where there is no dung to cover, the drill may be shallower, yet deep enough to make the ridge complete on the top.

In many districts the drilling is done by the ordinary single plough. In drilling with the single plough, the tail of it is purposely kept high, which leaves the bottom of the drill narrow. One passage of the plough is quite sufficient for either opening or closing, and many consider it preferable to the double mould-board plough, unless for earthing up potatoes. One point in favour of the single plough for drilling is, that by it the clods are thrown over the drill and fall into the bottom of the previous furrow, instead of being thrown, as by the drill-plough, into the centre of the drill, above the dung and under the seed.

Raised Drills on Strong Clays.—The system of raised drills is not so suitable for strong adhesive clays as for more friable soils. Still even in very stiff land it is often practised with success. On land of this kind—which, as we have seen, may be seriously injured by much tillage late in spring—perhaps the best plan is to form the drills in autumn or winter, after the land has been cleaned, dunged, and ploughed. In these open drills the land lies till the time of sowing, when a light harrow, chain-harrow preferably, is drawn over the land in the direction of the drills. Any artificial manure to be given is then sown broadcast, the drills are set up by the drill-plough, and the seed at once sown.

This provides a moderately fine tilth for the seed on the top of the drill, and yet it does not unduly promote evaporation. But it leaves the soil hard a few inches below the surface, preventing the roots from developing freely, and thus tending to make the crop a small one.

Drilling on the Flat.—In the midland and southern counties of England, the prevailing system is to sow the turnip seed on the flat surface in rows from 15 to 25 inches apart. As already explained, the main object in pursuing this plan is to avoid the dissipation of moisture, which is to a considerable extent unavoidable in raising the soil into loose ridges.

As a sort of general rule, it is recommended that, in districts with an average rainfall of less than 24 inches per annum, the flat system should be the prevailing one. A maximum crop is not likely to be obtained by this method, but in dry climates it is the safest, and is therefore extensively pursued in the south.

Width of Rows.—The rows on the flat are invariably narrower than raised drills. The most general width between the flat rows is from 18 to 20 inches, occasionally more and frequently less. With a greater width in the midland and southern counties of England, where the roots seldom attain the weights that are common farther north and in Ireland, the crop would fall off in yield per acre; yet it will be readily understood that the comparatively little space thus left between the rows on the flat does not permit of satisfactory horse-hoeing while the plants are growing. Moreover, the horse-hoeing cannot be begun so soon — not until the plants are sufficiently far up to ensure that they may not be unwittingly buried.

Broadcast Sowing of Turnips.—The broadcast sowing of turnips is now rarely practised. Where turnips are grown for the development of root, it is quite unsuitable.

Still, in certain cases, when a crop of turnips cannot be got in in time to grow roots satisfactorily, a useful supply of green food in spring may be provided, only in a good climate of course, by sowing in August, with the broadcast barrow, from 1¾ to 2 lb. per acre of turnip seed. For this purpose the ground is harrowed before and after sowing, and then rolled.

When not to be systematically thinned, turnips do better sown broadcast than in rows.

In some parts of the south, where an abundant supply of field food for sheep is a matter of great importance, land planted with beans is occasionally thinly broadcasted with turnip seed. In a mild

autumn, after the harvesting of the beans, the turnips develop a wonderful bulk of very useful food.

PROCESS OF SOWING.

The actual details of the process of sowing turnips depend upon whether the raised-drill or flat-row system is pursued, and what manure has to be applied at the time of sowing.

Dunging and Sowing in Raised Drills.

Taking first the system which prevails in Scotland, Ireland, and northern counties of England, we find that the detail work of sowing — assuming the land to be already cleaned of weeds, and sufficiently pulverised—consists, in succession, of opening the drills with the drill-plough, carting the dung and spreading it in the drills, perhaps drawing a light harrow along the drills, sowing artificial manures most likely broadcast, covering in the drills with the drill-plough, and sowing the seed with the drill-sower.

Simultaneous Drilling and Sowing.—Upon large holdings possessed of a sufficient force of horse and manual labour, all these processes go on at one time. The result in the crop is generally most satisfactory when there is no appreciable delay between the opening of the drills and the completion of the operation by the sowing of the seed. It is bad practice to open many more drills in one day than can be manured, closed, and sown before nightfall of the same day.

Stale Seed-bed Undesirable.—Turnip seed does not take kindly to a "stale" seed-bed. It comes away most satisfactorily when sown upon a freshly turned-up mould, fine in the texture, and tolerably moist — about two to four hours after the drills are closed in. When, therefore, it does happen that a portion of land has lain for a few days in finished drills unsown, perhaps on account of wet weather, some farmers consider it advisable to draw a light harrow along the drills, and set them up afresh with the drill-plough. This, however, takes time and labour when these can ill be spared, and unless the surface of the drills has become firmly packed or caked by heavy rains, the harrowing down and drilling up again may be dispensed with.

The Force Employed.—The arrangement of the force of horses and workers in sowing turnips on a large farm, so that there may be no delay and no collisions or interruptions to any of the force, requires considerable skill and forethought. We will assume that there are two drill-ploughs at work, and that the force for carting and spreading dung and sowing manure will be sufficient to keep these fully employed opening and closing drills during the entire day. The number of carts, and men to fill them, required to keep the two drill-ploughs busy, will depend upon the proximity of the dung-heap to the drills, and the quantity of dung to be applied per acre. With the dung in heaps at the end of the field, and not more than about 15 tons of dung per acre, four carts, with one or two men to assist the carters in filling, should be amply sufficient. Assuming that the two drill-ploughs would open and close about four acres per day, the four carts would thus convey to the drills about 60 tons of dung per day, perhaps from 18 to 20 loads each, in the full working day of ten hours.

Four or five workers—men, lads, or women—will be required to spread the dung, one man will sow the artificial manure, and another will follow all with the two-drill turnip-sower, drawn, perhaps, by a good-sized cob or farmer's pony. The steward, bailiff, or grieve (as the farm manager is variously called), or the farmer himself, usually sows the turnip seed, and as the turnip-drill takes two drills at a time, and the draught is very light, it will usually go over the whole day's opening and closing in rather less than a half-day. There will thus be employed in the "laying down" of about four acres of turnips eight horses, at least eight or nine men, and five or six lads and women for a whole day, and an additional man and horse for four or five hours. The cost, per acre, involved by the employment of this force would vary with the rate of wages, price of horses, and cost of horses' food in different districts and seasons.

Arranging the Force. — So as to avoid interruptions and ensure the maximum amount of work done in an efficient

and satisfactory manner, it is important to have the duties of each person clearly and intelligently defined and understood beforehand. About a dozen drills or so should be opened the night before, so that the full force may at once get to work in the morning.

Opening and Closing Drills.—As to the two teams with the drill-ploughs, the better plan is for the one to open and the other to close in the drills. In some cases the practice is for the two ploughs to follow each other, and open in the one direction and close in the other. This is apt to cause confusion and delay at the ends. In any case the amount of time occupied in turning at the ends is very considerable, far more than one would suppose without entering into minute calculations, and it will be readily understood that the loss of time at the ends would be appreciably greater if the teams have at every round to go along the ends of perhaps a dozen or fifteen drills, instead of each turning right round and going back on the same line. Moreover, by the one team opening and the other closing, there is less chance of the teams in the plough coming into contact with the carts on the end-ridges. This plan we would always adopt when there are two or more teams drilling.

In cases where there is only one drill-plough at work, the best plan is to open in the one direction and close in the other. This plan is followed where the single plough is used to open and close the drill with one furrow.

Another Method.—The following is another method of arranging the force, which some would prefer. In the evening before, 20 drills or so are opened, so that an immediate start may be made with the dunging operations in the morning. Three ploughs being used, they open the drills up-hill, and close them down the slope, if the field is not level. Three persons are placed at the dung-heap to load the four carts employed in dragging the dung. Each man throws the dung out of his own pair of carts, which come to the drills in rotation. This plan gives an interval of leisure to each man, so that he is not constantly kept in one position. A boy is sometimes employed in driving the carts between the dung-heap and the drills. When the first drill receives its dung, 4 spreaders are placed in divisions of equal length along the drill. This enables the manager to check the work of any spreader, which can be readily known. A machine for sowing manure, and another for sowing turnips, completes the operations. There is no waiting in any division of the work, but the whole proceeds in a regular manner. In this way 12 horses, and 15 men, women, and boys, can lay down from 6 to 8 acres of turnips per day, without any undue pressure.

Carting Dung into Drills.—The old-fashioned method of emptying the dung from the carts in small heaps in every third drill is still in vogue in many parts of England. In Scotland and Ireland it has long since given place to the much more expeditious and economical plan of throwing the dung in graipfuls from the cart into the drill as the horse moves along. A careful workman distributes the dung in this manner with admirable precision as to quantity, and it is left so as to make the work of the spreaders comparatively easy. The spreading of the dung is rendered still easier if the carter throws the graipfuls into the side drill (next to the drills already dunged) so that the wheel of the next cart may not go over the graipfuls, which would be the case if the dung were, as is often the case, thrown into the drill in the centre of the cart. With short well-made dung thrown out in this way we have often seen two smart women spread as fast as one team with a drill-plough could open and close in.

Cart for Steep Land.— Ordinary farm carts are employed in carting out

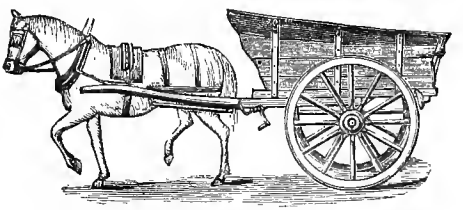


Fig. 348.—*Farm tip-cart.*

dung. In Div. vol. ii., p. 520, information is given as to the position of dunghills and

carting out dung, which should be consulted at this stage. In steep land, when a load has to be conveyed down-hill, a cart similar to that shown in fig. 348, made by the Bristol Waggon Works Company, will be found useful. It is a

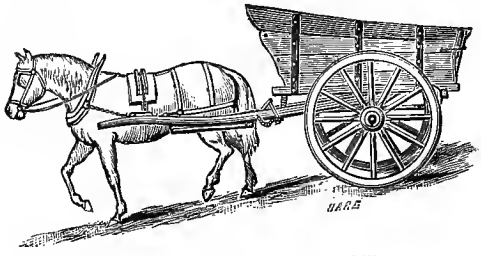


Fig. 349.—*Tip-cart going down hill.*

tip-cart, with screw arrangement, whereby the load may, as shown in fig. 349, be raised off the horse's back. Fig. 350 shows the same cart tipped so as to empty itself.

Dung-spreading Apparatus.—Appliances have been invented for spreading the dung as it is thrown from the cart, but as yet these have not come into general practice. A very useful apparatus of this kind is that shown in fig. 351, invented by Mr Davidson, Mill of Clola, Aberdeenshire, whose inventive genius has been hindered but not discouraged by the terrible calamity of total blindness. This machine is attached to the rear of the cart, is fed with the dung by the carter, and scatters the dung by its revolving prongs. For spreading dung on the flat surface, say for top-dressing meadow or pasture, or where the dung is to be ploughed in, this apparatus is most serviceable. For spreading in drills it is not so well suited. It is difficult to cover the dung perfectly when it is thus scattered all over the drills, instead of neatly spread in the hollow of the drill.

Sowing Artificial Manure.—The artificial manure is most generally sown broadcast by hand just before the drills

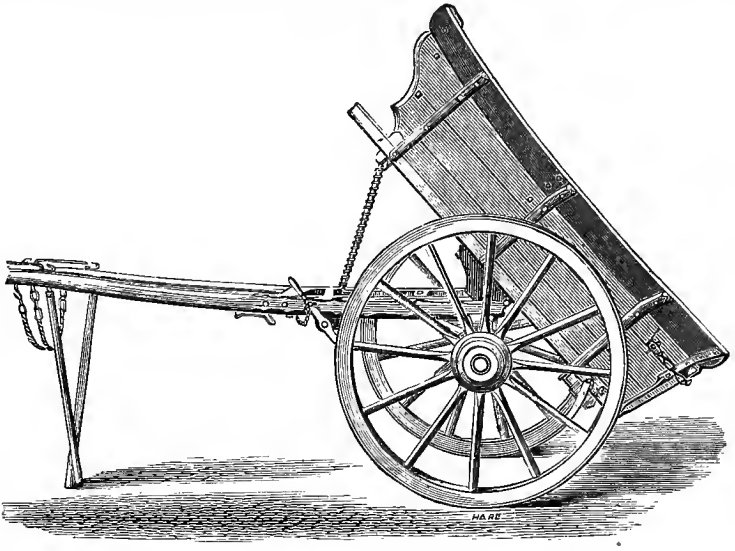


Fig. 350.—*Cart tipped.*

are closed in. It is a good plan to run a light harrow along the drills after the dung is spread, and before the artificial manure is sown. This helps to keep the quickly acting artificial manure nearer the rootlets of the young plants, and likewise still further pulverises the seed-bed. When there are many clods, some roll the drills before sowing the artificial manure. The manure is sown along the drill rather than broadcast, and may be done so quickly by a two-hand

sower that one man will keep two drill-ploughs going, and supply himself with manure from the bags or carts deposited at the ends of the drills.

Machines are also used for sowing the artificial manure in turnip-drills—both

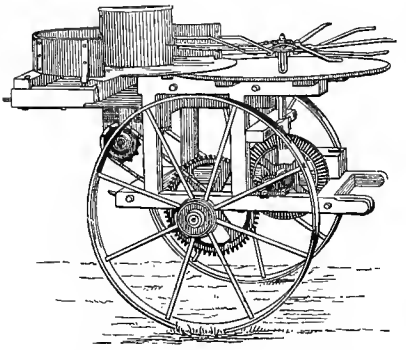


Fig. 351.—*Dung-spreading machine.*

broadcast and drill machines. See fig. 254, Div. vol. iii., p. 135.

Turnip Seed Drill.—Various have been the forms of turnip-sowing machines, and modes of distributing the seed. The old heavy square wooden-framed machine, and revolving seed-barrel once so common, is now seldom seen. Its weight was useful in heavy soils, but it was cumbrous, and the seed-barrel required great care to give an equal delivery. The improved modern turnip-drill sowing-machine is light, elegant, and easily managed. It consists of a simple iron frame, with shafts, handles, two rollers,

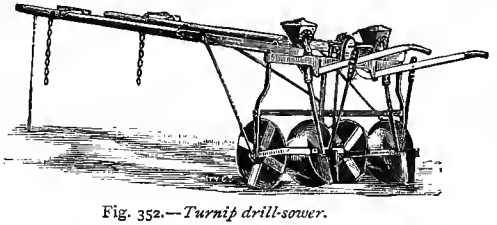


Fig. 352.—*Turnip drill-sower.*

seed-boxes, spouts, and coulters. The arrangements for working the seed-boxes, and for regulating the quantity of seed deposited, vary considerably, but the better known drills are all thoroughly efficient and reliable in working. The general formation of the modern turnip-drill is shown in fig. 352, which represents an excellent machine, made by James Gordon, Castle Douglas. Most of these modern drills can also be arranged with larger boxes for the sowing of mangels. Rollers can be attached to the rear of the machine, but these are only sometimes used.

Drilling Manure and Seed.—Manures are occasionally drilled along with the seed. In the raised drill system this is not often practised, as it is tedious and not of much practical advantage over broadcasting, unless where very small quantities are used. When large quantities of manures are used, they should be distributed over and mixed through the soil.

Water Drill.—The water drill, so common in the flat-sowing system of England, has been used with advantage in the north in dry seasons. It will sometimes secure a braird which would otherwise have failed. A stream of water, in which superphosphate may be dissolved, is run into the seed-rut. It acts as a moistener of the soil, and stimulant to the young plants.

Consolidating the Drill-top.—If the weather is very dry and the soil open, it is found advantageous to go over the drills a second time with the turnip machine, although no seed is sown. The rollers consolidate the drills, and make a braird more certain. A drill-roller made by Crosskill, Beverley, Yorks, is admirably suited for this purpose.

The braird seldom comes well if the soil is so damp that the rollers clog with earth.

Drill for Sowing on the Flat.—A machine of a different description is employed for sowing turnip seed in rows on the flat surface. It is in general form similar to the Suffolk drill, shown in fig. 264, vol. ii., p. 195, but is provided with means for sowing either dry artificial manure or water or liquid manure along with the turnip seed.

Water Drill.—A well-known machine of this kind is represented in fig. 353, Chandler's patent, made by Reeves & Son, Westbury, Wilts. This drill may be arranged for sowing, in rows on the flat, any kind of root or corn seed along with water or liquid manure. A tank

is provided for the water with which the artificial manure is mixed, and by which the manure is carried down the coulters into the rows along with the turnip seed. The flow of the liquid is regulated by a valve, and the quantity allowed varies from about 200 to 700 or 800 gallons per acre.

Dry Drill.—The machine for sowing root seeds and dry artificial manure together, in rows on the flat, is very similar to the water drill. The artificial manure is mixed with ashes, generally the ashes from burned weeds, and is carried on the drill in a receptacle, from which in regulated quantity it is deposited in the rows along with the seed.

Water and Dry Drills compared.—Both these drills are extensively used in the south of England. There is much difference of opinion as to their respective advantages and disadvantages. By the use of the water drill, the seed of course is provided with more moisture in the seed-bed. In average seasons this would most likely be an advantage, yet

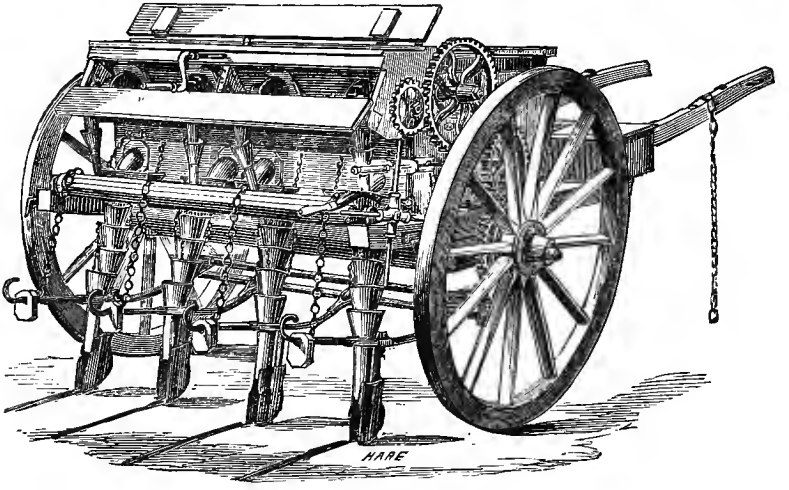


Fig. 353.—*Seed and water drill.*

it is maintained by many that it may often prove to be the reverse, or at any rate a doubtful advantage. In very dry seasons, for instance, it has been found in numerous cases that a stronger and more regular plant has been obtained from the dry drill than from the water drill. The reason assigned for this is that the superabundance of moisture at the very outset caused the seeds to germinate too rapidly, and set up a rate of growth which could not be maintained when the artificial supply of moisture began to fail.

Manure Injuring Seeds.—One important drawback to this system of applying artificial manures, guano especially, in close contact with the seed, is that the vitality of the seed is thereby apt to be injured or destroyed. Guano very often does much mischief in this way, sometimes killing from a third to a half of the seeds sown. The obvious remedy for this is not to sow the guano along with the seed, but to incorporate it with the soil before, as is done in the northern system.

Time of Sowing.

The period for sowing the Swedish turnip in Scotland usually extends from the 10th May to the 1st June; for yellows, from the 20th May to the 20th June. In the south of England, and most parts of Ireland, the sowing may be almost a month later. But there, as in Scotland, turnips sown early have, as a rule, the best chance of becoming a full crop. Notwithstanding an occasional season in which mildew attacks the earlier sown crops, it is an undoubted advantage, if the land can be properly

prepared, to sow the seed as early as possible after the 10th May.

In the south of England late turnips are frequently sown up till the end of August, and occasionally even in September. In these cases, however, heavy crops of solid roots are not looked for.

Quantity of Turnip Seed.

The quantity of seed required varies with the season and soil. The seeds of the Swedish variety are about one-fifth larger and heavier than those of the common turnip, and a correspondingly larger quantity must be used. Swedes sown in May require from 3 to 5 lb. of seed per acre. The latter quantity of good seed should be used in the earlier part of the season, if the soil is rough or of a stiff nature. If the season is somewhat advanced, and the soil finely moulded, from 2½ to 3 lb. may be sown. For yellows sown in May the quantity may be from 2 to 3 lb.; if sown in June, from 1½ to 2 lb. may be sufficient. We have sown as much as 7 lb. of Swedish seed per acre, and although every seed seemed to germinate, frost and fly withered up the seed-leaves and necessitated resowing.

Thick and Thin Sowing.—While thick seeding is expensive and injurious, in some seasons producing a rush of spindly plants, it is not prudent to sow too thinly. Not a few crops have been lost where a little more seed would have saved them. Moderately thick sowing sometimes helps to ward off an attack of the fly. As the season approaches midsummer, the weather gets warmer, the risk of fly diminishes, and a smaller quantity of seed is sufficient.

If the seeds could be evenly distributed, and if all could be depended upon to germinate and grow, 3 ounces of average yellow turnip seed, and 3½ ounces of swede seed per acre, would give a plant for every six inches of drill.

Selection of Turnip Seed.—Great care should be exercised in the selection and purchase of turnip seeds. It is sometimes mixed with old stock, or even with wild mustard seed killed by immersion for one minute in boiling water. Home-grown seed if fresh is more certain, and a smaller quantity will suffice. Fine plump seed is better than that which is small and immature, and will produce a stronger plant and heavier turnip.

Depth for Turnip Seed.

The depth to which turnip seed should be put into the soil varies with the state of the weather and the condition of the soil. In dry weather, with the soil moderately dry, the seed should be put fully an inch under the surface. In wet weather, with plenty of moisture in the soil, from a quarter to a half inch will be sufficient.

MANURING TURNIPS.

Dependence upon Manure.—It is quite essential for root crops of all kinds that a dressing of manure, usually very liberal, shall be given for their own special benefit. Turnips are gross feeders: they produce a great weight of material in a comparatively short space of time, and must therefore, if their success is assured, have within easy reach an abundant supply of readily available plant-food.

It is a characteristic of the turnip crops that they fail entirely upon impoverished soil. Upon a deteriorating unmanured soil grain will continue to produce some considerable yield long after turnips have failed upon it completely.

This peculiarity has been well shown at Rothamsted. There Norfolk white turnips grown for three successive years on two plots—one with no manure, the other with 12 tons of farmyard dung every year—gave in roots (omitting tops or leaves) the following results per acre:—

	No manure.		12 tons dung.	
	tons.	cwts.	tons.	cwts.
1843 .	4	3¾	9	9½
1844 .	2	4¼	10	15¼
1845 .	0	13¾	17	0¾
Average	2	7¼	12	8½

On another piece of land an unmanured plot was cropped continuously on the Norfolk four-course system,—roots, barley, clover (or beans or fallow), wheat,—and while the turnips coming at intervals of four years fell from 3 tons 5½ cwt. in the first year (1848), to 1 ton 6 cwt. in the second crop of roots in 1852, and to 5 cwt. in the tenth crop in

1884, the barley following after these miserable crops of roots, without any manure whatever, gave the respectable average of 31⅝ bushels per acre for the whole of the eleven crops grown in this way at intervals of four years.

It is thus evident that turnips readily exhaust the soil of the available supply of plant-food suitable to them, and that as foragers in poor soil they are not equal to the grain crops.

In quite an exceptional degree, therefore, turnips are dependent upon dressings of manure applied for their own special benefit. No farmer would ever think of attempting to grow turnips without an allowance of manure, in that or the previous season, no matter how fertile naturally or how high in condition the land may be.

An Exhausting Crop.—Assuredly the turnip crop is an *exhausting* crop. The fact that, in prevailing farm practice, it generally leaves the land better than it found it, is due, not to the influence of the roots, but entirely to the tillage and cleaning the land received in preparation for the roots, and to the surplusage in the dressing of manure.

It was at one time supposed and contended that turnips enriched the land by their large extent of leaf-surface absorbing nitrogen from the atmosphere, and leaving it in the soil for the benefit of succeeding crops. Careful investigations have shown that this idea is not well founded, and that the root crop, if wholly removed from the land, is the most exhausting of all the ordinary farm crops grown in this country.

These considerations all tend to emphasise the importance of the question of "manuring for turnips."

Elements Absorbed by Roots.—First, let us see what are the elements and the quantities of these elements absorbed by an acre of turnips. Reverting to the table on page 63, vol. i., giving the weight and average composition of farm crops in pounds per acre, we find that the figures relating to common turnips and swedes are as follows:—

	Turnips.			Swedes.		
	Roots, 17 tons.	Leaf.	Total crop.	Roots, 14 tons.	Leaf.	Total crop.
	lb.	lb.	lb.	lb.	lb.	lb.
Dry matter	3126	1531	4657	3349	706	4055
Total pure ash	218	146	364	163	75	238
Nitrogen	63	49	112	74	28	102
Sulphur	12.2	5.7	20.9	14.6	3.2	17.8
Potash	108.6	40.2	148.8	63.3	16.4	79.7
Soda	17.0	7.5	24.5	22.8	9.2	32.0
Lime	25.5	48.5	74.0	19.7	22.7	42.4
Magnesia	5.7	3.8	9.5	6.8	2.4	9.2
Phosphoric acid	22.4	10.7	33.1	16.9	4.8	21.7
Chlorine	10.9	11.2	22.1	6.8	8.3	15.1
Silica	2.6	5.1	7.7	3.1	3.6	6.7

Elements to be Supplied in Manure.—Now the next and all important question is, What proportion of these elements has to be supplied in manure? In ordinary farm practice the only essentials of manure are nitrogen, phosphoric acid, and potash. To most soils not by nature calcareous, lime has to be applied at intervals; but the functions of lime in the soil are well known to be so different from those of what are generally understood as manures, that we will not here embrace the question of liming, but will assume that the soil is sufficiently provided with it. Of the other elements mentioned in the above table the natural supplies will almost invariably be ample enough for the wants of the crop.

Subordinate Elements.—On some soils the application of magnesium, calcium, and sulphur has produced a considerable increase in the weight of the turnip crop. But the good effects seem limited to certain soils; and are

probably due more to chemical and mechanical agency than to the supplying of direct food to the plant. Thus caustic and carbonate of lime act upon soils by disintegration, and by causing a more rapid decay of the organic matter, liberate nitrogen, which acts as a plant-food to all crops, and in the turnip give an increase of shaw equal to that obtained by a small application of sulphate of ammonia. The addition of sulphuric acid, especially in a free state, must act upon and change some of the soil constituents.

Uncertainties in the Manuring Question.—Confining attention, therefore, to those three important elements of plant-food—nitrogen, phosphoric acid, and potash—we have to consider what quantities of each of these should be applied to the different kinds of turnips in different conditions as to soil and climate. This, unfortunately, is not a simple mathematical question. There are so many uncertainties as to the character and contents of the soil, and so many disturbing influences in climatic variations, that the farmer, however scientific, careful, and capable generally, must always be to some extent working by chance. Moreover, the farmer has to keep in view the important considerations of profit and loss as well as the perfection of the crop. He is not content to discover merely what quantities of nitrogen, phosphoric acid, and potash would be likely to ensure a full crop of turnips. His great object is to learn what quantities of these elements should be applied in order to secure the greatest possible return for the outlay involved. The prudent farmer, like all prudent business men, works for profit. He wants not merely a *big* crop but a *paying* one as well.

Now in practice it is found that to apply to the land the exact quantities of essential manurial elements which analysis shows that the particular crop removes, would not be efficient and economical manuring. The reason for this is twofold. In the first place, there are the stores of fertility already in the land, which may be sufficient to provide much of all, and all or the greater portion of some, of the elements. On the other hand, the whole of the plant-food in the manure applied may not, in an available form, come within the range of the roots of the crop for which it was intended.

For guidance in manuring, therefore, we have to rely largely upon practical experience as well as upon scientific formula. For instance, the general system of cropping pursued on the farm has to be considered,—whether the manure to be applied to the root crop has to serve for future crops, for what other crops, and for how many years the manuring is intended to last. This, indeed, is a most important point in arranging the allowance of manure for turnips,—a point which has been fully discussed in the chapter on "Manures and Manuring." Another important consideration is the manner of utilising the crop of roots—whether they are to be in whole or in part consumed on the ground by sheep, or entirely removed.

Turnip-tops are now seldom removed from the land: they are either consumed on it, along with the roots, by sheep, or they are cut off when the roots are being pulled and ploughed in. In considering the after fertility of the land, the elements absorbed by the tops would therefore not have to be taken into account. In manuring for the roots, however, the entire contents of the crop must be kept in view.

Nitrogen, Potash, and Phosphoric for Turnips.—It is found, then, that crops of common turnips and swedes would absorb about the following quantities of nitrogen, potash, and phosphoric acid per acre:—

	Common Turnips, 17 tons (of bulbs).		Swedes, 14 tons (of bulbs).	
	Bulbs and tops.	Per ton (of bulbs).	Bulbs and tops.	Per ton (of bulbs).
	lb.	lb.	lb.	lb.
Nitrogen . . .	112.0	6.88	102.0	7.28
Potash	148.8	8.58	79.7	5.69
Phosphoric acid . .	33.1	1.95	21.7	1.55

These yields per acre are above the average for England, and below what would be reckoned good crops in Scotland, Ireland, and the best turnip districts of the north of England. From these figures, however, it will be easy for any farmer by a simple mathematical question to form a useful *estimate* as to the quantities of these elements of plant-food which his crops of turnips are likely to absorb. We use the word estimate advisedly, because it should be remembered that such figures as these, giving the average composition of turnips, cannot be held to represent the composition in all cases with precise accuracy. Yet by multiplying the number of tons he expects to grow by the quantities per ton shown above, the farmer will come sufficiently near the actual facts to afford him a useful guide as to the supplies of these important elements of plant-food which should be available to his crops.

Chief Manure for Turnips. — To judge by these analyses of turnips, one would conclude that potash and nitrogen should bulk more largely than phosphoric acid in manures for turnips. In practice, however, it is found that such is not the case. The dominant element in all special manures for turnips is phosphoric acid. It must in some form or other be applied to all soils, and in many cases constitutes the sole application for the turnip crop.

Experiments in Pure Sand. —Many useful and interesting sets of experiments have been conducted with the various elements of plant-food applied to different farm plants in pure, utterly barren sand. The conclusions pointed to by experiments of this kind carried out by Professor Jamiesou of Aberdeen, are stated by him as follows:—

1. That neither sulphur, nor magnesia, nor lime is required to be in *manures.*

2. That nitrogen, phosphorus, and potassium are the only elements that are required in manures.

3. That nitrogen influences chiefly the cereal crop.

4. That phosphorus influences chiefly the root crop.

5. That potassium does not influence any of the usual crops so much as nitrogen and phosphorus do, nor has it shown a dominance over one class of plants more than another.

It was found in this barren sand that the turnips came to nothing where nitrogen was withheld; that when phosphorus was withheld the turnip crop was as complete a failure as when everything was withheld; and that without potassium the turnip crop was very poor and deficient.

Experiments on Average Soils.— In the years from 1879 to 1882, Mr John Milne, Mains of Laithers, Aberdeenshire, made experiments with test manures for turnips in general field cultivation on forty-seven farms in the north-east of Scotland, representing all classes of soil found there. To one plot all the chief ingredients found in the ash of turnips, as well as nitrogen, were applied. From each of the other five plots one ingredient was withheld in turn.

The average deficiency of crop in plots where nitrogen was omitted was 11 per cent; where phosphorus was omitted, 33 per cent; where potassium was omitted, 15 per cent; where magnesium was omitted, 4 per cent; and where calcium sulphate was omitted, 1 per cent.

These indicate the relative potency of the different ingredients in growing turnips on average soils, and show the powerful influence of phosphorus, the moderate influence of potassium and nitrogen, and the inconsiderable influence of calcium, magnesium, and sulphur, on the weight of the turnip crop.

Gloucestershire Experiments.—An elaborate series of experiments upon various manures in the growth of swedes was carried out by Professor Wrightson, under the auspices of the Cirencester Chamber of Agriculture, in the years 1868-1876. The conclusions arrived at are summarised as follows:[1]—

1. That poor land, and in poor condition, derives the greatest benefit from artificial dressings.

2. That land in high condition has been proved in many cases to derive little or no benefit from the use of artificial dressings.

3. That land in this (Cirencester) neighbourhood appears to be satisfied with moderate dressings, and the use of

[1] *Fallow and Fodder Crops*, 113.

heavier dressings is not attended with commensurate results.

4. That 3 cwt. of ordinary mineral superphosphate per acre has given the most economical result (along with dung) during several years' experience over hundreds of plots.

5. That guano, nitrate of soda, organic matter, and even farmyard dung diminish the germinating power of swede seed, and cause a blankness in the crop when they are brought into contact with the seed.

6. That guano and nitrate of soda applied to the growing swedes increase the crop, but scarcely to an extent to warrant their general use.

7. That the average increase in swede crops, from the use of 3 cwt. of superphosphate (along with dung) amounts to 5 tons 6 cwt. per acre. That in some cases the increase has been *nil*, while in others it has been as much as 14 tons per acre.

Nitrogen for Turnips.

In farm practice it has not been found that any considerable direct application of nitrogen has been repaid by an increase in the turnip crop. Yet it has been proved that the presence in the soil of readily available nitrogen is essential for the healthy growth of the crop.

Atmospheric Nitrogen Insufficient.—With their broad leaf-surface, turnips have been credited with the ability to draw a considerable quantity of nitrogen from the atmosphere. There is reason, however, to suspect that the powers of the root crop to procure nitrogen for itself and succeeding crops in this way has been greatly overestimated. At any rate it is evident, as shown in Professor Jamieson's experiments in barren sand (p. 356), and by other similar experiments, that the turnip in its very earliest stages cannot abstract from the atmosphere sufficient nitrogen for its development.

Nitrogen in the Soil.—Thus a certain supply of nitrogen in the soil itself is indispensable. Practical experience has tended to show that, in most soils in good average condition as to cultivation and fertility, the turnip will find as much nitrogen as it can profitably take up. Certainly wherever a reasonable quantity of short or well-rotted farmyard manure is applied, there will be little or no need for any further direct application of nitrogen.

On the other hand, where no dung can be spared, and where it is known or suspected that the soil is deficient in available nitrogen, the application of a small quantity will most likely produce an increase in the crop.

Rothamsted Experiments with Nitrogen for Turnips.—In a series of experiments at Rothamsted with Norfolk white turnips and swedes grown for four successive years (1845-1848), the following results—per acre—were obtained:—

Norfolk White Turnips.

	Roots.		Leaves.		Total.	
	tons.	cwts.	tons.	cwts.	tons.	cwts.
No manure	1	4	0	17	2	1
Ammonia salts=45 lb. nitrogen	1	7	1	0	2	7
Mineral manures alone . .	8	4	2	14	10	18
Do. with 45 lb. nitrogen . .	9	18	4	6	14	4

Swedes.

	Roots.		Leaves.		Total.	
	tons.	cwts.	tons.	cwts.	tons.	cwts.
No manure	2	6	0	6	2	12
Ammonia salts=45 lb. nitrogen[1]	3	17	0	6	4	3
Mineral manures alone . .	7	5	0	10	7	15
Do. with 45 lb. nitrogen . .	8	18	0	11	9	9

[1] In a later experiment of a similar kind, nitrate of soda gave rather better results than ammonia salts.

From these figures it will be gathered:

1. That in all cases the nitrogenous manure made a slight, but in no case a great, influence upon the produce.

2. That by itself the nitrogenous manure was more effective upon swedes than white turnips.

3. That in the case of white turnips the increase traceable to nitrogenous manures occurred chiefly in the leaves or tops, so that in this case there was very little gain in feeding material from the application of the ammonia salts.

Nitrogen producing Leaves.—The significance of this last result is indicated by the fact that in the plot which received the highest nitrogenous manuring there was nearly as much dry solid matter per acre in the leaf—which for the most part only becomes manure again—as in the root, which may be said to be the only edible portion of the crop.

With the swedes the results are altogether more satisfactory. With these nitrogenous manure had very little influence on the leaf, the proportion of which to root is always small in the swede. Such increase as the ammonia salts effected in the swedes took the shape of useful feeding matter in the bulb.

Dr Gilbert's Conclusions.—In summarising the results of the Rothamsted experiments upon different manures for turnips, Dr Gilbert submits the following conclusions in reference to *nitrogenous manures*:—

1. It is entirely fallacious to suppose that root crops gain a large amount of nitrogen from atmospheric sources by means of their extended leaf-surface. No crop is more dependent on nitrogen in an available condition within the soil; and if a good crop of turnips is grown by superphosphate of lime alone, it is a proof that the soil contained the necessary nitrogen. In fact, provided the season be favourable, the *condition* of the land, as far as nitrogen is concerned, may be more rapidly exhausted by the growth of turnips by superphosphate than by any other crop.

2. A characteristic difference between the uncultivated and the cultivated turnip root is, that the cultivated root contains a much lower percentage of nitrogen, and a much higher percentage of non-nitrogenous constituents, especially sugar, by the accumulation of which the percentage of nitrogen is reduced. Yet it is under the influence of nitrogenous manures that the greatest amount of the non-nitrogenous substance — sugar — is produced.

3. If nitrogenous manures are used in excess—that is, in such an amount as to force luxuriance, that the roots do not properly mature within the season—there will be, not only a restricted production of root, but an undue amount and proportion of leaf.

4. Excess of nitrogenous manure tended to lower the percentage of dry matter and increase the percentage of nitrogen in the roots.

English Practice.—Notwithstanding the importance which the Rothamsted experiments place upon nitrogen for the turnip crop, it is not the rule in English practice to apply nitrogenous manures directly to turnips. As to this point, Professor Wrightson remarks: "Ammonia salts and nitrate of soda, although producing an increase of leaves, do not greatly increase the yield of bulbs. Their effect, when applied alone on exhausted soils, is trifling; but where there is an abundance of available mineral food, an increase is no doubt effected by their application. This increase is, however, not commensurate with the expense, and the wiser system is to employ superphosphates in root cultivation, and hold back the ammonia salts and nitrate of soda for application on the cereals or grasses."[1]

Experiments with Nitrogen at Carbeth.—At Carbeth, Killearn, Stirlingshire, in the years 1882 to 1885, Mr D. Wilson, jun., M.A., F.C.S., conducted an interesting series of experiments on the growth of yellow turnips with various manures. In those years 38 plots on different fields were dressed with 10 to 13 tons of rich covered-court dung, and to 19 of these plots ¾ cwt. of nitrate of soda, or its equivalent in sulphate of ammonia, was also applied per acre. The results were:—

	Average of 19 plots, per acre.	
	tons.	cwts.
Dung	20	12
Do. and ¾ cwt. nitrate of soda or sulphate of ammonia . . .	21	4

[1] *Fallow and Fodder Crops*, 70.

The increase from the nitrogenous manure was thus only 12 cwt. per acre; and as the ¾ cwt. nitrate of soda cost about 8s., the 12 cwt. extra of roots entailed an outlay at the rate of 13s. 4d. per ton. Plainly, therefore, in this case it was not profitable to apply nitrogenous manure with dung.

In the same series of experiments (which are reported fully in the *Transactions of the Highland and Agricultural Society*, for the years 1884, 1886, and 1887) artificial manures alone were also tried in the growth of turnips. In this case the application of nitrogenous manure gave a very different result.

Of 34 plots dressed with artificial manure, 17 received 1½ cwt. per acre of nitrate of soda or its equivalent in sulphate of ammonia, and 17 plots no nitrogenous manure, but the same treatment otherwise. The result was almost regularly an increase of one-fifth in the produce of bulbs from the nitrogenous manure. In other words, when in an unfavourable turnip year the plots without nitrate of soda gave 12 tons of roots, the nitrate of soda plots gave 14½; while in a good year with 20 tons without nitrate of soda, there was grown a 24-ton crop with the nitrogenous manure.

Mr Wilson thus arrived at the conclusion that while turnips are not, upon soils in average condition, nearly so dependent upon supplies of soluble nitrogenous manures as the cereals, it will pay in most soils, when growing them without dung, to use a little nitrate of soda, say fully 1 cwt. per acre.

Nitrogen is most likely to be required for roots when the soil is deficient in organic matter, and where the climate is warm and dry.

Potash for Turnips.

Although potash bulks largely in the analysis of the root crop, the application of potash in the form of manure would not in all cases be followed with advantage. In most soils there are great natural supplies of potash, and, as a rule, all the additional potash required will be provided in a moderate dressing of farmyard dung. But in certain soils, notably those of a light sandy and gravelly nature, and in cases in which little or no dung is applied, it is more than probable that the addition of a small quantity of potash to the dressing of manure would be profitable.

Many instances have been observed of quite a remarkable increase in the crop from a moderate allowance of potash. These of course have taken place where all the elements and conditions necessary for the production of a large crop of roots are present excepting available potash. In manuring, the farmer should never forget the significance of the law of minimum—that law whereby the produce is limited, not by the combined quantity of all the elements present in the soil, but by the producing power of the supply of the essential element present in the smallest proportion.

Thus when potash is deficient, the application of it is followed by a marked increase in the crop.

Potash is usually most deficient in light gravelly soils in poor condition. Still it is the exception rather than the rule for land to be in need of potash for turnips. The conclusion which the majority of experimenters and observing farmers have arrived at is, that unless there is good reason to suspect that the particular field is deficient in available potash, it need not be included in the manure.

An Excess of Potash Injurious.—Indeed it has been found in several cases that an excess of potash has injuriously affected the yield of roots, as in the Highland and Agricultural Society's experiment referred to on page 180 of Divisional vol. iii. At Carbeth, Stirlingshire, Mr Wilson had similar experience. Potash salts equal to 2 cwt. of kainit per acre were tried on 22 plots, alongside 22 similar plots without potash, but dressed also with dung as the other plots also were. The results were:—

	Average of 22 plots, per acre. tons.	cwts.
Dung alone . . .	21	9
Dung with 2 cwt. kainit .	20	13

Decrease due to the potash, 16 cwt. per acre.

Tried at Carbeth without dung on four different soils, potash gave a profitable increase in roots in only one soil. In the other cases the supply of potash already in the soil was sufficient. As

to excess of potash, Mr Wilson remarks that "the mineral acids combined in these salts seem to be set free, and to do mischief to the crop."

Mr Wilson therefore advises the withholding of potash, unless it is believed from actual experiment or observation that there is a deficiency of it in the particular field.

Test the Soil.—Here again let us urge the farmer to watch closely and *test* every year the condition of his land as to its supplies of the leading elements in plant-food. See pp. 91-94 in Divisional vol. iii.

Phosphates for Turnips.

In all manures specially adapted to turnips, the dominant element should be phosphoric acid. Under all circumstances, in all soils and situations, with dung and without dung, it is the almost invariable practice to furnish turnips with a phosphatic dressing in some form or other.

Phosphatic Manures Alone.—Upon average soils in good condition as to tillage and general fertility, wonderful crops of roots are frequently grown by the application of phosphatic manures alone. Thus at Rothamsted, under conditions not favourable to such large yields of roots as are obtained in Scotland, superphosphates alone (consisting of 200 lb. bone-ash dissolved in 150 lb. of sulphuric acid per acre) produced, on an average of nine crops grown in a four-course rotation, 8 tons 4½ cwt. of swedes per acre—or 6 tons 10 cwt. more than was grown upon an unmanured plot alongside.

Phosphates with other Manures.—But while this result is in itself remarkable, it is important to note that in the same series of experiments at Rothamsted, another plot dressed with "mixed manure" produced in the nine years an average of over 15½ tons per acre. This "mixed manure" was both complete in composition and liberal in quantity. It consisted of 300 lb. of sulphate of potash, 200 lb. sulphate of soda, 100 lb. sulphate of magnesia, 200 lb. bone-ash, 150 lb. sulphuric acid, 100 lb. sulphate of ammonia, 100 lb. chloride of ammonium, and 2000 lb. of rape-cake per acre.

It will be interesting to present these results here in tabulated form:—

	Average per acre of 9 crops of Swedes in 4-course rotation.					
	Roots.		Leaves.		Total Produce.	
	tons.	cwts.	tons.	cwts.	tons.	cwts.
Unmanured . .	1	14⅞	0	5⅛	2	0
Superphosphate .	8	4½	0	16¼	9	0¾
Mixed manure . .	15	12¼	1	13⅞	17	6⅛

Too much Reliance on Phosphates.—There is a tendency in some parts of the country to place too much reliance upon phosphatic manures alone for the turnip crop. This should be guarded against, for with imperfectly balanced manuring the results cannot be fully satisfactory. It is more than probable that in many cases where phosphatic manures alone are applied, the addition of a small allowance of nitrogenous and potassic manures would very substantially increase the produce of the crop.

This would not likely be the case in land which is naturally fertile and in good heart from liberal manuring with dung and other lasting manures in previous years. But in land in poor or medium condition, it would, in all probability, be advantageous to add small quantities of nitrogenous manures and potash to the phosphates.

Superphosphate Manuring Exhausts the Soil.—In the economical manuring of any particular farm crop, it is important to keep in view the after condition of the soil—that is, the effect which, under the dressing of manure now applied, the crop is likely to exercise upon the general fertility of the soil.

In the manuring of turnips this consideration demands more attention than many farmers have been in the habit of giving to it. For it is tolerably well authenticated that by the injudicious—the excessive or exclusive—use of superphosphates for turnips, the standard fertility of the soil has in many cases been appreciably lowered. Indeed, as we have already seen, Dr Gilbert states that "there is perhaps no agricultural practice by which what is

termed the *condition* of land—that is, the readily available fertility due to recent accumulations—can be to so great an extent exhausted by one crop, as by growing turnips by superphosphate of lime alone, provided, of course, that the season is favourable."

This point was illustrated by the series of experiments at Rothamsted just referred to. On the plot which received no manure in all the ten years, the barley which succeeded the root crops averaged no less than 31⅝ bushels per acre; while on the plot which received for the turnips 200 lb. of bone-ash, and 150 lb. of sulphuric acid converted into superphosphate every fourth year, the average produce of the barley fell to 26⅞ bushels per acre. The advantage of the liberal dressing of mixed manures applied to the roots was seen in the barley crop, which rose to an average of 40¼ bushels per acre.

Recouping the Soil.—The exhaustion of the soil which thus takes place by the growth of turnips from exclusive or excessive dressings of superphosphates may be prevented, or rather recouped, by the consumption on the ground, not only of the root crop but also of some other food, such as cake or grain, by sheep. This is extensively done in many parts of the country, and is especially commendable where dung cannot be spared for the root crop. Indeed it is the rule in many districts to consume on the land by sheep the whole or greater part of any section of the turnip crop which had not received farmyard dung and was grown solely by artificial manure.

Phosphates with Dung.—In the four years' experiments at Carbeth, Stirlingshire, already referred to, the only artificial manure sown along with dung which repaid its cost in an increased crop of roots was superphosphate, applied at the rate of from 3 to 5 cwt. per acre. From a large number of plots in different fields and in different years, dressed with from 10 to 13 tons of rich covered-court dung, the addition of 5 cwt. of superphosphate gave an average increase of 2 tons 10 cwt. per acre in bulbs. The dung given here was sufficient to supply all the phosphoric acid required by the roots. The increase from the addition of superphosphate is therefore attributed mainly to its assisting the plant with easily assimilated phosphoric acid before it could lay hold of the more slowly acting dung. Another advantage is, often one of great importance, that the quickly acting superphosphates force the plants more rapidly past the stage in which they are attacked by the fly.

Phosphates without Dung. — Mr Wilson also experimented with phosphates without dung, and with and without the aid of other artificial manures. On land at Carbeth which is evidently above average fertility, the average produce of roots without dung or phosphates was 7 tons 17 cwt. per acre. With 8 cwt. 25 per cent superphosphate, the average produce rose to 17 tons 19 cwt.—an increase of 10 tons per acre.

Cheapest Phosphate for Turnips.—An important question, as to which there is a good deal of difference of opinion, is that of the most economical form of phosphate for the turnip crop.

From 1840 to 1870, Peruvian guano and roughly crushed bones, with the occasional addition of dissolved bones and superphosphate, were the manures chiefly employed to supply the nitrogen and phosphates to the turnip crop. Since the Chincha Island deposit of guano became exhausted, the other deposits, being inferior in ammonia and high in price, are comparatively little used. Crushed bones, more finely ground than formerly, are still in much repute for turnip manure in all light soil districts; while on the heavier soils dissolved bones and, still more, superphosphate, have become the general manures.

Mineral Phosphates. — Notwithstanding some opinions to the contrary, carefully conducted experiments have shown that phosphates from mineral sources, such as rock guano, coprolites, Carolina phosphates, and the phosphate from the Thomas-Gilchrist steel slag, when finely ground, act on the turnip crop almost as well and nearly as fast as the phosphate in finely crushed bones, while the mineral phosphates can usually be bought at a much less price per unit. So long as mineral phosphates are much cheaper, the farmer in favourable circumstances as to soil and climate may do well to use them, in part at least, in place of crushed bones; taking care that *the*

grinding is as fine as possible, and avoiding all the phosphates of alumina, and the crystalline apatite, which latter should always be dissolved before application.

Discrimination in use of Mineral Phosphates.—To use undissolved mineral phosphate successfully as a turnip manure, the farmer must exercise not a little discrimination. Some mineral phosphates will give excellent results in one soil, while in another soil, not very different in appearance, the effects will be disappointing. Indeed, the potency of phosphates varies so much, owing to physical condition, pulverisation, and structure, as well as owing to the varying influence of soils apparently similar, and also climate, that their general unpopularity is easily understood, for the average farmer cannot be expected to study the varieties, soils, and influences which render the use of this manure profitable. An exception is phosphatic slag, which is invariably effective on light and medium soils.

The various forms of phosphate are fully described in the chapter on "Manures and Manuring," pp. 102-120, Divisional vol. iii.

Superphosphates.—Superphosphate of lime, the characteristics of which are fully discussed at pp. 116-118, Divisional vol. iii., is now extensively used as the source of phosphoric acid for turnips. In great parts of England, where the soil and climate are dry, it is indeed almost the only form of phosphates now used for turnips along with dung. In many cases it has been found the most economical form of phosphatic manure for this crop, producing a heavier yield than the same value of crushed or dissolved bones.

At Carbeth, Mr Wilson compared superphosphates with equal money's worth of ground Charleston phosphate. He obtained in four years an average of 10 per cent more weight of bulbs from the superphosphate than from the ground mineral phosphate. Mr Wilson also contrasted the superphosphate with Thomas slag. The results again were in favour of the former, at the existing prices of the two articles. Mr Wilson likewise considered the phosphates in guano dearer than those in superphosphate; but in contrast with the same value of *steamed bone-flour*, the superphosphate failed at Carbeth to sustain its supremacy. Steamed bone-flour mixed with superphosphate produced 13 cwt. more per acre than an equal money value of superphosphate alone. Mr Wilson adds that, making allowance for the nitrogen contained in steamed bone-flour, more phosphoric acid is got for the same money in this form than in superphosphate.

Along with dung, Mr Wilson prefers superphosphate (mainly for its quick action) to all other forms of phosphates. Without dung, he would provide the phosphates in a mixture of steamed bone-flour and superphosphates.

The Aberdeenshire experiments, described on pages 170 to 175, Divisional vol. iii., have a very direct bearing upon this point. Note in particular what is said (page 173) as to the influence of phosphates rendered soluble by sulphuric acid upon the tendency to "finger-and-toe," and as to fineness of grinding or perfect disaggregation (pages 172 and 174) being as effective as dissolving in sulphuric acid.

Climate and Soil to be Considered.—In deciding as to the form of manure used, the characteristics of the climate and soil must be carefully considered. As to this point, Mr John Milne, Mains of Laithers, Aberdeenshire, who is a practical chemist as well as an extensive experimenter and successful farmer, remarks:—

"In cold wet districts, or if the crop is late in being sown, the quantity of soluble phosphate should be increased, as its effect is to force the crop to early maturity. In these circumstances, if farmyard manure is applied, little or no nitrogenous manure should be used, as its tendency is to keep the crop growing longer, and thus retard its maturity. Undissolved mineral phosphates always act best in warm early seasons, and do not show quite so well as soluble phosphates in cold wet years.

"In manuring, the farmer should be guided by the quality of his soil, the period of sowing, and probable character of the weather. If his soil is rough or stiff, the sowing late, or the climate cold or wet, a pretty large proportion of soluble, precipitated, or very finely ground

phosphate is advisable. If the soil is soft, the season early, and the climate dry, the phosphate need not be so finely divided, and a larger proportion of nitrogen may be beneficially used."

Farmyard Manure for Turnips.

In prevailing farm practice this is the standard manure for turnips. It is the rule—which, however, has a good many exceptions—to apply the whole or the greater portion of the farmyard dung to the potato, turnip, and mangel crops. The prevalence of the practice is a tolerably sure indication that a dressing of dung is well suited to the turnip crop.

We have seen (p. 353) how marked was the influence of repeated dressings of dung in growing turnips at Rothamsted—12 tons of dung every year having in three years raised the produce of white Norfolk turnips from 9½ tons to over 17 tons per acre.

Supplementing Dung.—But while a dressing of dung is highly beneficial to the turnip crop, it may be found advisable to supplement it with some more quickly acting fertilisers, such as superphosphate, nitrate of soda, and potash. Much will of course depend upon the condition and quality as well as the quantity of the dung. Well-rotted dung acts more quickly than fresh dung, while if it has been enriched by the consumption of concentrated foods, it will be still more efficacious. It is highly important that the plants be pushed forward rapidly in their earliest stages, so that they may get beyond the ravages of insects. For this purpose a dressing of some quickly acting phosphatic manure will be a valuable supplement to the more substantial but slower farmyard dung. As we have seen, superphosphate or a mixture of very finely ground mineral phosphate and steamed bone-flour will likely be most suitable. When dung is applied to soils in good condition, only a small quantity of any readily acting phosphate is required, and when quick growth is wanted superphosphate will serve the purpose very well. Still, if the price per unit, instead of per ton, and the residue of ingredients left in the soil for future crops, are taken into account, superphosphate is found to be at present the most costly manure in the market.

Too much Forcing Injurious.—On the gravelly and lighter soils, and especially for yellow turnips, too much forcing in the first stages is injurious, except in cases of very late sowing. Its usual effect is to aggravate the difficulty of singling the plants in proper time. It renders the crop more apt to set and even to mildew at a later stage. The turnips will be of inferior feeding quality; and the early rapid growth distinctly increases the tendency to anbury.

Is Dung Essential in Turnip Culture?—This question has been much discussed. It is still the subject of difference of opinion. Many noted agriculturists, including Professor Wrightson, contend that good crops of swedes cannot be grown without dung. Others hold that it is not by any means essential, and that better results will be obtained by applying the dung to other crops, such as potatoes, or on pasture or meadowland, and growing the turnips entirely or mainly with substantial artificial manure. It is going too far, we think, to hold that swedes cannot be grown advantageously without dung. As a matter of fact, good crops of swedes *are* grown without dung; and the feeling is gaining ground that some proportion of the excessive dressings of dung which are often applied to swedes might be more advantageously utilised for other purposes.

Assuredly it is most desirable that a substantial dressing of good farmyard dung should be available for swedes. It is the best foundation of all for a successful crop; and, as a rule, it will be found the safest practice to devote the main portion of the dung to the swedes. But while dung is probably necessary to ensure a maximum crop of swedes, it is not absolutely essential for the production of a profitable crop. In some cases it may be desirable to grow a greater breadth of swedes than the available supply of dung will cover; and this may be done by the use of artificial manures. Generally, however, it is deemed prudent to substitute yellow turnips when the dung becomes exhausted.

It would be unnecessarily restricting the operations of the educated and skilful farmer to tell him that he must not attempt to grow swedes without farmyard dung.

The softer varieties of turnips are grown very extensively, and with great success, without the slightest particle of dung, great care, skill, and liberality being of course necessary in these cases in the use of artificial manure, so as to maintain the fertility of the land. Unless the turnips are consumed on the land by sheep, it will most likely be necessary to top-dress some of the other crops which follow upon the land which received no dung for the roots.

Quantities of Manures for Turnips.

The quantities of manure applied to the root crop vary greatly throughout the country. The ruling influences are the climate, the natural character of the soil, its condition as to accumulated fertility or exhaustion, the purposes for which the roots are intended, and the general system of farming pursued.

Yield and Quantity of Dung.—The consideration which most largely regulates the amount of manure—that is, where the objectionable practice of applying all the manure for the rotation with the root crop has been abandoned—is the suitability of the district and the field for the production of a heavy or light crop of roots. Where a crop of 25 to 30 tons per acre is to be looked for, the allowance of manure must, as a matter of course, be much larger than where the yield is not likely to exceed 12 to 15 tons. These figures roughly represent the respective yields of the best turnip-growing districts of Scotland, Ireland, and the north of England, and in the midland and southern counties of England, and thus in the latter the prevailing quantities of manure applied are much less than in the green isle and north of the Humber.

The general questions to be considered in deciding as to the quantities of manure for the various crops have already been fully discussed in the chapter on "Manures and Manuring," Divisional vol. iii. pp. 89-185. See in particular pp. 126-135. Here, therefore, a very few notes as to the prevailing customs will suffice.

Scotch Dressings.—In Scotland, in the north of England, and in Ireland, the allowances of dung vary from 5 to 20 tons per acre, and the accompanying dressings of manure from 3 to 8 or 10 cwt. of phosphatic manures, ½ to 3 cwt. of nitrogenous manures, and ½ to 3 cwt. of potash salts. More general quantities of dung run from 8 to 15 tons. Along with from 10 to 12 tons of dung, from 3 to 5 cwt. of phosphatic manures, 1 cwt. of nitrate of soda or sulphate of ammonia, and 1 to 1½ cwt. of kainit, would be a liberal dressing. For swedes some farmers give as much as 12 to 14 tons of good dung, 4 cwt. of mineral superphosphate, 2 to 3 cwt. crushed or dissolved bones, 1 cwt. of nitrate of soda, and 1 cwt. of kainit. Others curtail the artificial manure to about 3 or 4 cwt. superphosphate, ½ cwt. of nitrate of soda, and ½ cwt. of kainit. Often the two latter are omitted altogether; still more often the potassic manure is omitted, and the small allowance of nitrogenous manure included.

Advantage of Heavy Dressings Questionable.—Several of these dressings of artificial manures along with dung are assuredly very heavy. Many careful and successful farmers are doubtful as to the economy of such liberal and costly additions to the supplies of dung. By his carefully conducted experiments at Carbeth, Stirlingshire, Mr Wilson was led to the conclusion that the usual practice in many turnip-growing districts of expending from 30s. to £2 per acre upon artificial manure, to apply along with dung, is not a profitable one, and that in many of these cases half the rent of the land might be saved by reducing this outlay.

Certainly the once practised method of applying manure—dung, bones, and guano—to the turnip crop to serve for the entire rotation, has been exploded as thoroughly unsound. The allowance of dung for the rotation may of course be, and is still, applied to the roots, and with good effect; but with the artificial manure the case is entirely different. In regard to these, it is a safe rule to apply no more at any one time than you expect the first crop will profitably utilise or repay. A reasonable exception to this rule would be a dressing of crushed bones, particularly for grass land.

Moderate Dressings of Dung.—When the supply of dung is not suffi-

cient to go over the entire root break, it is a good plan to lessen the allowance per acre, and make the dung go as far as possible, increasing the quantity of artificial manure in proportion. Better far give 8 tons to the entire break than 12 tons to a certain portion, and none to the remainder—better especially for the after fertility of the land.

Artificial Manures alone. — When no dung can be spared, the allowance of artificial manures has to be very liberal. In some cases the allowance is as high as from 5 to 6 cwt. superphosphate, 2 to 3 cwt. steamed bone-flour or crushed or dissolved bones, 1 to 2 cwt. of nitrate of soda, and 2 to 3 cwt. of kainit. In other cases, again, from one-half to two-thirds of these quantities are supplied, the potash often being omitted altogether. In many cases superphosphate at the rate of 8 to 10 cwt., and 1 to 2 cwt. of nitrate of soda, constitute the sole dressing. Others use a portion of finely ground mineral phosphate.

But the variations in the individual dressings are so numerous that it would be impossible to fairly represent them here.

Southern Dressings. — The most general dressing in England, where a crop of from 12 to 18 tons is expected, is from 8 to 12 tons of dung and 3 cwt. of superphosphate per acre. A small allowance of guano or nitrate of soda, from ½ to ¾ cwt. per acre, is often drilled along with the superphosphate and the turnip seed, but this plan is regarded by many leading authorities as unprofitable.

Necessity for Individual Judgment.—In arranging the quantities of manure for turnips, as in most other farm operations, the circumstances of each individual case must be carefully considered. General rules are subject to many variations, which each farmer must decide upon for himself. A careful study (aided by a few experiments, which should always be going on) of the condition of the soil and its capabilities under favourable circumstances as to fertility will be the safest guide as to the most profitable quantities of manure to apply. It is a point in farm management which demands the very best attention from the farmer.

Application of Manure for Turnips.

The general methods of applying manures, and the principles upon which these should be regulated, have already been dealt with (pages 126-135 Divisional vol. iii.) What is said there should be carefully studied in connection with the culture of turnips.

Dung.—As to the merits and demerits of the various practices of applying dung in the autumn, and on the flat surface, and in the drills in spring, enough has been said in the pages just referred to.

Upon heavy lands where the dung is available in time, the best and most general practice is to plough down the dung with a shallow furrow in the autumn or early in winter.

Where this has not been done, and where the turnips are to be sown on the flat surface, the dung is spread on the flat surface and ploughed down with a moderate furrow early in spring. Late dunging in this case is not to be commended, as the rank dung would be liable to unduly encourage the escape of moisture by keeping the surface soil open.

The general practice where the turnips are grown in raised drills, is to spread the dung in the bottom of the drills at the time of sowing the seed; yet, as just explained, if the land is stiff and the dung available, autumn dunging, even with sowing in raised drills, is in many cases a beneficial method. It lessens work at sowing-time, and the dung helps to disintegrate the adhesive soil.

Artificial Manure.—The most general practice with all kinds of artificial manure for turnips, is to apply it at the time of sowing the seed, as described on page 350.

Southern Customs. — In England, wherever the turnips are sown in rows on the flat surface, the artificial manure is generally drilled in along with the seed with the dry or water drill, as already explained (p. 351). Guano, nitrate of soda, and sulphate of ammonia are, however, liable to injure the germinating power of the turnip seed when thus brought into contact with it. To obviate this, the nitrogenous manures (when such are given) are sometimes sown broadcast, and harrowed in just before or

after the seed is sown. Indeed, in many cases in England all the artificial manures are thus sown broadcast, although with a light application sown in this way the crops grown in rows on the flat are very often disappointing. Broadcasting artificial manures is more satisfactory with raised drills, as in this case the scattered particles of the manure are gathered towards the plants by the operation of the drill-plough.

For the flat-row system the best plan perhaps is, where the artificial dressing consists entirely of superphosphate, to drill the whole of it along with the seed, and where other manures as well as superphosphates are given, to drill the greater portion of the superphosphate along with the seed, and sow the remainder with the other manures broadcast, and harrow in, following with the roller.

Potash is in many cases found to give the best results when sown in the previous autumn.

Top-dressing Turnips.—The practice of top-dressing turnips is rarely pursued. If nitrogenous manure is required, some consider it a good plan, especially in wet climates, to hold it back till the plants are about ready for singling, and then apply it in the form of a top-dressing of nitrate of soda.

Singling and Hoeing.

Influence of Weather.—The seed-leaves usually appear in from three to seven days after sowing. The plants

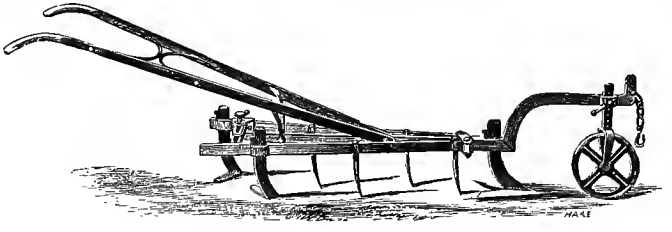


Fig. 354.—*Scotch drill-scuffler or horse-hoe.*

grow rapidly in fine dry weather, if the nights are free from frost. Until the

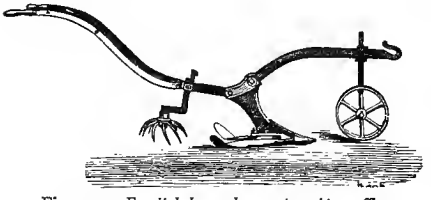


Fig. 355.—*English horse-hoe or turnip-scuffler.*

plants are of considerable size, heat and dryness favour their growth, while at this stage much rain is not favourable, and on clay soils in wet seasons they are sometimes to be seen with red leaves, "sojered," after which they seldom develop into a satisfactory crop. At a later stage, when the plants are 20 to 30 inches across, dry weather is unfavourable, and on dry soils they will luxuriate in wet weather. If the subsoil is retentive, however, a very heavy rainfall is injurious, and will sometimes almost drown the crop and prevent its farther growth. A dry warm autumn is always favourable for bulbing; but after December heat starts the roots and tops anew, tends to run the tops to seed, and deteriorates the quality of the bulb.

Turnips should be singled when the leaves measure about an inch across.

Drill-harrowing or Horse-hoeing.—But before singling or hand-hoeing is commenced, several operations may be performed which will make the labour of hoeing more easily performed, and by farther loosening the soil tend to promote the growth of the plants. If the weather is dry, the drills should be run

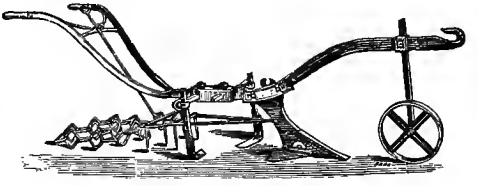


Fig. 356.—*Horse-hoe and harrow.*

between by a drill-harrow or scuffler, let in as deeply as possible. But the width stirred should not exceed twelve inches,

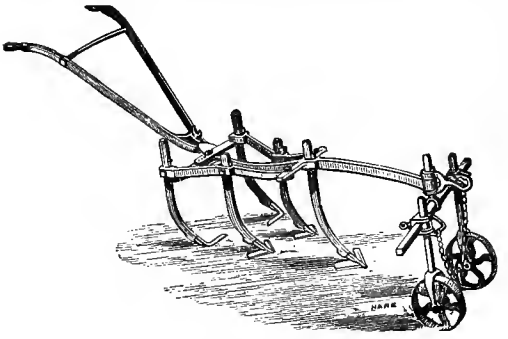


Fig. 357.—*Turnip horse-hoe.*

for if set wider the land will be too much drawn away from the plants before the process of singling is finished, and the raised drill too much reduced.

Fig. 354 (Sellar & Son, Huntly) represents a type of a drill-harrow, scuffler, or horse-hoe, which is largely used in Scotland. An ingenious and modern English turnip horse-hoe or scuffler, made

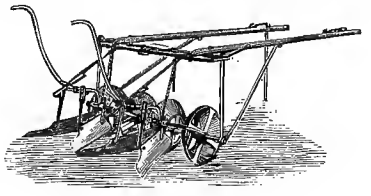


Fig. 358.—*M'Kidd's drill-scarifier.*

by S. Corbett & Son, Wellington, Salop, is represented in fig. 355. Other two very useful implements of the kind, but of different patterns, and made respectively by T. Corbett, Shrewsbury, and Vipan & Headly, Leicester, are shown in figs. 356 and 357.

Horse-hoes are made to take two or more drills at a time. English scufflers or horse-hoes are made so as to work either in the raised drills or in narrower rows on the flat system.

Harrowing across Flat Rows.—In the south a sort of drag-harrow, in some cases similar to a light Scotch drill-harrow, is drawn right across the flat rows before the first horse or hand hoeing, the object being to loosen the surface-soil, pull out surface-weeds, and thin out the plants a little. Careful turnip-growers in the north do not approve of disturbing the plants thus early and in such an irregular fashion.

Drill-Scarifier.—A drill-scarifier, first brought out by Mr M'Kidd, Thurso, Scotland (and shown in fig. 358), is used on some farms in the north for paring away the sides of the drills, thus destroying weeds, and bringing the drills into the intended form, leaving less to be done by the hand-hoe. The implement, as made by various firms (that here illustrated being made by T. Hunter, Maybole), somewhat resembles an improved turnip-sower without the seed-boxes. The centres of the bevelled rollers

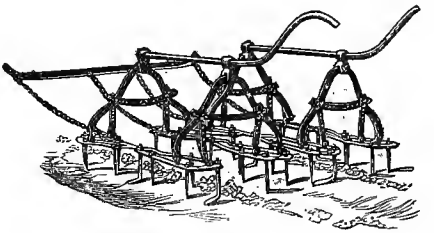


Fig. 359.—*Dickson's turnip-cleaner.*

are left out, so as not to injure the plants, and four steel plates for paring the edges of the drills are attached to the frame. The plates can be attached to an ordinary turnip-sower, if the rollers are made so that the centre part can be removed.

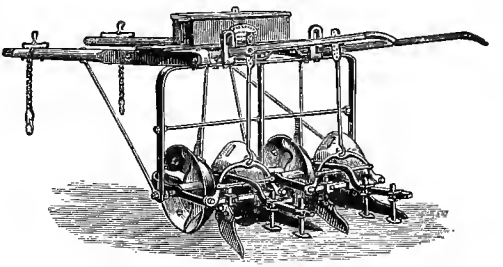


Fig. 360.—*Briggs's turnip-thinner.*

Turnip-cleaner.—Dickson's double-drill turnip-cleaner, made by Thomas

Hunter, Maybole (shown in fig. 359), is a useful implement for working up close to the turnip plants.

Thinning-machines.—To perfectly single turnips by machine is practically impossible. Several more or less successful machines have, however, been constructed to thin the plants in raised drills, and render the work of singling more easy to accomplish either by hand or hoe. If the soil is fine, and the braird equal, these machines are an undoubted saving of labour. Two successful machines of this kind are here illustrated—fig. 360, patented by General Briggs of Strathairlie, Largo; and fig. 361, patented by T. Wardlaw, Toughmill, Dunfermline.

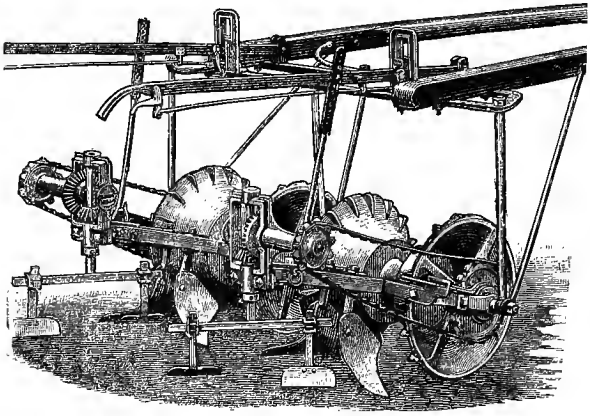


Fig. 361.—*Wardlaw's turnip-thinner.*

Hand-hoes.—The hand-hoe used in thinning turnips is a simple instrument. Yet even in it improvements have been introduced in recent times. Instead of the shaft or handle being closely attached to the blade, it is now often made with a bow-shaped attachment, as shown in fig. 362. A hoe of this pattern works more lightly and cleanly than the hoe of the old shape, shown in fig. 363. The length of the blade of the hoe varies from 5 to 8 inches, according to the width usually left between the plants.

Fig. 362.—*Improved hand-hoe.*

Process of Hand-hoeing on Raised Drills.—As already mentioned, the turnips should be thinned when they measure about an inch across, when the tops are well into the rough or second leaf. The hoer ought to be taught to draw the hoe towards himself or herself in pulling out the spare plants, and to work as lightly as possible. If the plants are pushed away from the hoer, a deeper hold of the soil must be taken, a greater quantity of soil will be removed from the remaining turnips, the drills will be more pitted and levelled, and the plants thus too much denuded of support. Hoers generally take pride in their work, striving to leave the drills as high and symmetrical, and as smooth in the surface as possible, all weeds thoroughly removed—uprooted, not cut—and the plants thinned to precise distances as arranged, care being taken to leave strong well-formed plants, and never two together.

Fig. 363.—*Turnip hand-hoe.*
a Thin iron plate. *b* Eye of plate. *c* Wood shaft.

Hoeing-matches.—In some parts of the country hoeing-matches in the evening are quite an institution, and there is often great enthusiasm amongst the rival hoers—the farmers' families and servants of the surrounding district. These friendly contests are very properly encouraged by farmers, for they stimulate tasteful and careful hoeing, which in turn has a considerable influence upon the yield of the crop—far greater than would be at first thought imagined.

Good and Bad Hoeing.—It is quite within reason to say that the difference in the yield between a carefully hoed piece of ground—hoed as we have in-

dicated above—and another hoed carelessly, with irregular intervals between the plants, weak plants left instead of strong, two plants sometimes left together, and the drills cut deeply into, and weeds only partially removed,—in short, between good and bad hoeing,—may very easily amount to from 2 to 4 tons per acre!

Hand-hoeing in Flat Rows.—Here, also, the plants should be drawn towards the hoer. Indeed, as will be readily understood, the great part of the hand-hoeing on the flat must be done in this way, as it is more difficult to push out weeds in the flat row than on the raised drills.

Speed of Hoers.—The amount of work done by hoers varies according to the soil, the width of the drills or rows, the intervals left between the plants, the thickness of the seeding, and the stage at which the hoeing is done. If the soil is clean in raised drills, the plants not too thick, and taken at the proper size, an average hoer should overtake an imperial acre in from twenty-five to twenty-seven hours. If circumstances are very favourable, it may be done even in twenty hours; and if very unfavourable, it may take forty to forty-five hours to single an acre. If the drills are well scarified, the work is much lighter.

Expert men-hoers often go over the ground almost as quickly in the flat-row system of the south, where the rows may be only from 18 to 20 inches apart. But it would be all the better for the crop if a little more pains were taken with the hand-hoeing than is often the case.

In Scotland, Ireland, and the north of England, women do a large portion of the hoeing; but in the midland and southern counties of England it is performed almost entirely by men and lads.

Thinning by Hand.—In some cases when a greater breadth of plants comes forward at one time than can be gone over with the hand-hoe as quickly as may be considered desirable for the sake of the crop, thinning by hand is resorted to. This is an expeditious method of averting injury by the overcrowding of the young plants. In the long-run, however, it increases the cost of thinning and hoeing.

The better system of management, therefore, is to have a sufficient force of hoers to overtake the thinning as the plants become ready for the process. In average seasons the sowing is done so that the plants come forward to the hoe in breaks; but irregularities in the weather may upset this arrangement, and result in a pressure of work at certain times in the hoeing season, perhaps justifying recourse to hand-thinning if an extra force of hoers cannot be obtained. In any case, some farmers, who are particularly careful of their turnip crop, would give the preference to the hand-thinning, because by it a little more care can be exercised in leaving the strongest plants.

In some parts the thinning is done partly by the hoe and partly by hand. The hoers go on before, taking gaps out of the row of plants, leaving little bunches of perhaps three to half-a-dozen plants, while lads and women follow, and single these bunches by the hand, taking care to leave in the strongest and most promising-like plant in each bunch.

Transplanting Turnip Plants.—Common turnip plants cannot be transplanted with success. With swedes, however, transplanting is often done, to fill up blanks in the drills. The results are fairly satisfactory, sometimes yielding nearly half the weight of an average bulb.

Distance between Plants.

There has been much discussion, and there is still wide difference of opinion, as to the distances which should be left between turnip plants. The prevailing practice in this matter has undergone many modifications and alterations since the introduction of turnips as a regular field crop throughout the country generally.

Mr Stephen Wilson's Experiments.—Probably no one has given closer or greater study to the botany of the common farm crops than Mr A. Stephen Wilson, North Kinmundy, Aberdeenshire, author of that interesting work entitled *The Botany of Three Historical Records*. Mr Wilson carried out in the

three years prior to 1879 an exhaustive series of experiments, extending over several farms, on numerous fields and with different kinds of turnips and swedes, with the view of throwing light upon the subject of turnip-thinning. In the *Transactions of the Botanical Society of Edinburgh*, 1876-77, and in a pamphlet entitled "Agricultural Botany: Turnip Singling," published by John Rae Smith, Aberdeen, in 1879, Mr Wilson records the results of these experiments, which are unquestionably the most elaborate, searching, and reliable of the kind that have as yet (1889) been made in this country. It will be interesting to contrast here the conclusions arrived at by Mr Wilson with the prevailing practices throughout the country as to the distances left between turnip plants.

Peculiarities of Turnip Seed.—It is calculated that there are about 140,000 seeds of the common turnip (the seed of swedes being a trifle heavier) in a pound weight, and that with drills 27 inches wide and 3 lb. of seed sown per acre, about fourteen times as many seeds are planted as are intended to grow. As the result of carefully conducted experiments,[1] Mr Wilson found that large turnip seeds produced heavier bulbs than smaller seeds; and by way of emphasising the importance of selecting good seed and good sound heavy-producing varieties of roots, he remarks:[2]—

"Our turnip seeds are not to be regarded as mere indifferent starting-points, which, like a gun-ball answering the charge of powder, will go forward the obsequious messenger of some grasping phosphate. A turnip seed is a fully formed plant. It has two leaves tightly wrapped round its root. And within the substance of these two leaves, or cotyledons as they are called, it has a store of milk or pap, needing only to be moistened by water to enable it to start in the world and walk a little without manure of any kind. So long, indeed, as its own sandwiches hold out, most other kinds of food are poison. But no two seeds are alike, or equally furnished for the journey in the drill; and therefore we must study the character and capacity of our little embryos. Some of them have a faultless constitution, and if their disagreeable neighbours were hoed out of the way, would acquire the enviable brassical corpulence of eight or ten pounds. Others have a taint of some insidious disease, or the hopes of their youth are obscured by the fly, or their roots are set upon by a myriad of the spores of plasmodia, and thus they may protract a miserable existence under a diameter which would be discreditable to a parsnip. We have therefore to endeavour to find out to what weight the average plant will attain. We have to find out the extent of ground in which a turnip will attain its greatest dimensions. We have to find out whether the greatest individual dimensions are consistent with the greatest crop. And, involved in this, we have to ascertain whether our plants should be permitted to go on to their greatest size, or should be checked at a certain bulk by limitation of the spaces in which they grow. In virtue of certain, presently unknown, properties, some varieties naturally acquire a greater bulk than others; and we have to consider whether our crops, without any additional outlay of manure, might not be augmented by a more general adoption of the most prolific varieties."

Weight without Singling.—Assuming that 3 lb. of the seed of common turnips were allowed to grow at equal distances in 27-inch drills, there would be about 420,000 plants in an acre, with little more than half an inch to each plant. In this space the plants would probably attain a weight of nearly half an ounce each. This would give a total weight of about 6 tons per acre without thinning.

To what distance should the plants be thinned in order to secure the maximum weight per acre? This was the question which Mr Wilson endeavoured to answer.

Trials at 6, 9, and 12 Inch Distance.—In 1877 Mr Wilson experimented with greystone globes and swede turnips, thinned in 27-inch drills to 6, 9, and 12 inches between every two plants. The following were the results:—

[1] *Trans. Bot. Soc., Edin.*, 1876-77.
[2] *Ag. Bot.*, 10.

Interval.	No. of Plants per Acre.	Greystone Globes.		Swedes.	
		Average Actual Weight.	Total Theoretical Weight per Acre.	Average Actual Weight.	Total Theoretical Weight per Acre.
		lb.	tons.	lb.	tons.
12 inch . . .	19,360	1.70	14.29	2.50	21.61
9 " . . .	25,813	1.42	16.36	1.95	22.47
6 "	38,720	1.15	19.88	1.54	26.62

The year 1877 was unfavourable for turnips, and these weights are far below the average of Mr Wilson's district of Aberdeenshire, which is noted for its production of turnips. Moreover, this experiment was conducted on a small scale, so that a calculated instead of an actual weight per acre had to be shown. It was therefore decided to carry out an experiment in the following year on a much more extensive scale.

From this first trial it is seen that, although the individual roots were heaviest with the greatest width, yet by far the greatest weight per acre was obtained with the short intervals of 6 inches—the 6-inch distance beating the 12-inch by 5.15 tons per acre with greystone globes, and by 5 tons per acre with swedes; while the advantage of the 6-inch over the 9-inch was 3.50 tons per acre with greystone globes, and 4.15 tons with swedes.

Twelve Inches Discarded as too Great.—This result in regard to the 12-inch distance so fully coincided with trials previously conducted by Mr Wilson, that he decided to discard that interval as greater than could be justified in practice.

Trials with 6, 8, and 9 Inch Intervals.—The next series of experiments were restricted to intervals of 6 inches, 1 link or 7.92 inches (practically 8 inches), and 9 inches. These trials were conducted in 1878 on seven fields on seven different farms, and all the work of planting, singling, numbering, and weighing was done by Mr Wilson himself. The results were as follows:—

	Common Turnips. Average of several varieties.			Swedes. Average of several different kinds.		
	Actual Weight of Plant.	Actual Weight per Acre.	Theoretical Weight per Acre.	Actual Weight of Plant.	Actual Weight per Acre.	Theoretical Weight per Acre.
	lb.	tons.	tons.	lb.	tons.	tons.
6 inch	1.84	28.64	31.88	1.83	25.48	31.61
8 " } 9 " } . . .	2.40	26.61	28.78	2.22	24.22	26.52

Deficiency in Weight at Greater Distances.—Mr Wilson points out that in order to give as heavy a total yield per acre, the roots at 9-inch and 1 link intervals would need to bear in weight to the weight of the roots grown at intervals of 6 inches the proportions of 150 and 132 to 100. How far short they fell of this will be shown at a glance in the following table:—

	Common Turnips.			Swedes.	
	6 Inch.	1 Link.	9 Inch.	1 Link.	9 Inch.
Proper proportion for equal weights per acre	100	132	150	132	150
Actual average proportion . . .	...	114	138	119	126
Percentage deficiency in weight at the greater distances	...	18	12	13	24

Mr Wilson's Conclusions.—In referring to the details of his experiments, Mr Wilson remarks that over the seven fields on the seven farms, with several different kinds of turnips, they show such uniformity as hardly leaves any doubt that in general 6-inch intervals will ensure a heavier crop of swedes or of common turnips than either 8 or 9 inch intervals. Indeed, he says he satisfied himself, after all his trials with many sorts of turnips, in favourable and unfavourable seasons, under ordinary rotation of cropping, that 6-inch intervals will give a heavier crop than any wider interval.

And these conclusions derive special importance from the fact that Mr Wilson is no mere theorist or enthusiastic reformer. He is, indeed, a most painstaking, scientific, and thoroughly impartial experimenter. We have no hesitation in saying that the most implicit reliance may be placed upon the accuracy and genuineness of his experiments.

It is, of course, a different matter to consider how far the conclusions arrived at by Mr Wilson might be advantageously extended into ordinary farm practice.

Prevailing Intervals.—These experiments by Mr Wilson, and other more limited trials, have tended to shorten the intervals left between turnip plants in certain districts. The prevailing intervals are still, however, considerably wider than Mr Wilson would advise. Where the system of raised drills obtains, the intervals most general are from 10 to 12 inches in the cases of swedes, and from 8 to 10 inches for common turnips. A good deal depends upon the known habit of the particular variety of roots, whether it is inclined to develop large or medium bulbs. The soil and climate must also be considered, for under conditions which favour the growth of large roots the intervals should be longer than where small roots are expected.

The space between the plants should of course vary with the width of the drill, or between the rows of plants if the crop is grown on the flat surface. The most general width of the raised drill is 27 inches, and, as will be readily understood the plants may be left nearer each other in these wide drills than in the much narrower flat rows which abound in the midland and southern counties of England. These flat rows are usually only from 16 to 20 inches apart, and so the intervals between the plants there most frequently vary from 13 up to 16 inches for swedes, and about 2 or 3 inches less in the case of other varieties of turnips.

Growing Roots in Squares.—There is little doubt that the maximum weight per acre of roots would be obtained by growing them at equal distances apart in all directions, in squares of one foot or 14 inches for instance. Indeed it was found by experiments in Canada that a better crop resulted from placing the plants in the centre of a square unit than in the middle of an oblong unit, as in the case of common drilling.

Advantages of Drills.—But there is a practical advantage in the drill and row systems which far outweighs any loss in the produce of roots. The cleaning and tilling of the land are facilitated, and thus by growing them in tolerably wide rows or drills the root crops take the place of the costly "fallows" of olden times.

Medium and Large Roots.—One

important point which should be kept in view in discussing and deciding as to the best intervals to be left between turnips is the ascertained fact that, as a rule, medium-sized bulbs show a higher specific gravity and contain a greater percentage of useful feeding material than exceptionally large-sized roots. This is the case in a very marked way with the common varieties of turnips. It is slightly different with most kinds of swedes. "Large" and "small" are comparative terms. It is claimed for most of the improved varieties of swedes that the larger they grow the more nutritious they become. What is meant in this case of course is, not roots of abnormal dimensions, but what the practical farmer would regard as large roots grown under normal conditions.

The object of every farmer should certainly be to grow a big—that is, a heavy—root in relation to the space allotted to it. What has been taught by investigations as to the nutritive properties of roots of different sizes is not that small varieties of roots should be cultivated, but that the maximum quantity of good feeding material per acre is more likely to be obtained by growing (at shorter intervals) a greater number of medium-sized roots than a smaller number (at longer intervals) of abnormally large roots—this, too, even although in both cases the gross weight of the produce may be equal. In other words, three medium roots—"big-little" roots—weighing each 3 lb., and grown in, say, 30 inches of an ordinary drill, will, as a rule, contain less water and more solid nutritive matter than two bulbs of 4½ lb. each, grown in the same area of ground.

Moderate Intervals.—The teaching of modern investigation is therefore decidedly in favour of shortening the intervals between the turnip plants. For common turnips from 6 to 9 inches should perhaps be the range in drills from 26 to 28 inches wide, and for swedes about 2 inches more. In flat rows from 16 to 20 inches wide, suitable intervals would be from 9 to 11 inches for common turnips, and from 11 to 14 inches for swedes. In dry seasons favourable to mildew the wider intervals will likely give the best results. The free exposure of the plants to the atmosphere, as in wide singling, has a tendency to check the development of mildew.

Irregularity in Growth of Turnips.—Notwithstanding every care taken to single the plants at equal distances, it will usually be found after the crop has made some progress in growth that irregularities appear both in the distances apart and in the size of plants. Unless the seeding is very liberal, plants are apt to appear and grow somewhat irregularly, especially in dry weather. A good hoer will strive to leave a strong plant, even if an extra inch or two beyond the distance intended. After hoeing, plants are occasionally pulled up by crows and wood-pigeons, and cut across by wireworm and grub-worm. Some of the plants receive other injuries which prevent growth. The smaller and more backward get shaded and overtopped. The available supply of manure is appropriated by their more vigorous neighbours. The manures, especially dung, are seldom too well spread; so that an average field will show not a little irregularity both in size of bulbs and distance apart. Indeed it is only on the most fertile and easily pulverised soils, and under the most favourable circumstances of soil and climate, that the bulbs approach equality of size and regularity of distance apart.

After Cultivation.

The cultivation required by turnips after the singling has been completed consists of hand-hoeing once or twice, and horse-hoeing between the rows of plants two, three, or more times. The season and condition of the land as to weeds and tilth will regulate the number of hoeings.

About ten or fourteen days after singling, the horse-hoe or drill-harrow is run along the drills or between the rows of plants, to stir up the soil and eradicate weeds. The second hand-hoeing may follow in a few days, the hoers removing all weeds left by the horse-hoe or drill-harrow, and loosening, but not displacing, the earth around the plants. If in any case two plants have been left together, in singling one should now be carefully pulled by hand.

Care in Hoeing Strong Plants.—It is no doubt beneficial, except in times

of drought, to stir the soil around the plants even after they have grown almost to cover the drill with their tops. In this operation, however, the greatest care must be exercised not to cut the rootlets, which are now spreading like net-work in all directions, and which cannot be cut or seriously disturbed without less or more injury to the crop. For this reason the third hand-hoeing is often abandoned.

Earthing-up Turnips.—It is sometimes found beneficial, chiefly on wet soils, to earth-up turnips immediately after the second hand-hoeing. The main advantage of this is, that surplus surface-water is carried away more freely. In dry soils, however, the earthing-up may do more harm than good. Some of the rootlets may be cut or injured by the plough, and their development thus impaired. Then the sharp, deep furrows are troublesome, even dangerous, in case of sheep feeding on the roots, as sheep may get upon their backs in the ruts, and perish if not released in time.

If earthing-up is to be done at all, it should be carried out as soon as possible after the second hoeing. The younger the plants the less will be the injury or disturbance to the rootlets. But the earthing-up of turnips is neither a general, nor, as a rule, a commendable practice.

Turnip Pests.

Birds of Prey.—No sooner is the seed of the turnip sown than animals begin to prey upon it. Pigeons are eager to pick up the uncovered seeds. Various small birds, such as linnets and finches, run up the drills just as the cotyledons are appearing above ground, pull up the plants, and devour the softened seeds. In some seasons these birds do such injury as necessitates the resowing of acres of turnips. When the turnip gets into the rough leaf, rabbits and wood-pigeons nip off the leaves and thus retard the growth of the plants.

Protecting the Seeds.—The seeds may be protected from birds by rubbing them with red-lead before sowing. Paraffin has also been tried with success, but it is not so safe as dry lead.

Insect and Fungoid Injury.—The insects and fungi which prey upon turnips are numerous. These are dealt with in a chapter in this volume devoted specially to the insect and fungoid pests of the farm.

Conditions influencing Nutrition in Turnips.

Careful and observing feeders find marked differences, not only in the keeping, but also in the feeding properties of the several kinds of both swedes and yellow turnips in cultivation.

Soil and Nutrition in Roots.—The soil has a decided influence on the quality of the turnip crop. A heavy clay soil produces roots of good and nutritious quality. A light medium soil will also produce roots of a fattening quality, but a moorland soil with red subsoil or pan will produce bulbs that are less nutritious. On moorland soils turnips seldom grow much in autumn after the tap-root reaches the subsoil, and small bulbs of poor quality are the result. Peaty soils, if they contain a mixture of other ingredients, usually produce large roots, but of soft and spongy quality, producing dark-coloured dung in the cattle using them.

Manures and Nutrition in Roots.—Professor Jamieson of Aberdeen, who conducted for the Aberdeenshire Agricultural Research Association an elaborate series of experiments on the growth and composition of the turnip crop, found the composition of the bulb to be largely influenced by the manures applied.

The application of nitrogen increased the percentage of water, and lowered the percentage of solids in the bulbs. In the crop grown in 1876, the forty-five yellow turnips he selected, grown with nitrogenous manures, contained an average of 8.31 solids. Twenty-five grown without nitrogenous manures, contained an average of 9.18 solids. Ten selected Swedish turnips, manured with nitrogenous manures, contained an average of 10.19 solids; ten not manured with nitrogenous manures, an average of 10.43 solids.

Subsequent experiments, and also those made by Professor Jamieson in Huntingdon and Kent, confirmed these results. He found that small-sized bulbs yielded about one per cent more solid matter than large bulbs. Other experimenters have found the solids diminished by the use of soluble phosphate in the manure.

Nutrition in Large and Small Roots. — Dr Aitken made an analysis of turnips grown on sixty plots, manured variously, at Pumpherston experimental station in 1882; and Mr David Wilson, jun., Carbeth, made analysis of turnips from twenty-seven plots, also variously manured, at Carbeth, Stirlingshire, in 1884. The following are the results:—

	Average Weight of each Bulb.	Percentage of Dry Matter in fresh Turnips.	Composition of 100 parts Dry Matter.							Percentage of total Nitrogen Albuminoid.
			Albuminoids.	Non-Albuminoid Nitrogen × 6·25.	Extractive Matter free from Nitrogen.	Sugar.	Ash.	Fibre.	Total Nitrogen.	
	oz.									
Average analysis of turnips from 60 plots, Dr Aitken	27.6	8.71	7.72	1.34	74.26		5.98	10.79	1.446	85.2
Average analysis of turnips from 27 plots, Carbeth .	25.4	8.91	6.06	6.76	15.23	52.95	7.47	11.54	2.056	47.3

It would thus seem that whatever tends to increase the size of bulb, or weight of the crop, has a tendency to increase the percentage of water, and lower the percentage of solid matter in the bulbs, whether it be by the application of nitrogenous manures, the use of much soluble phosphate, or wide distances between the plants; and that the composition and quality of the yellow turnip is more easily affected than those of the swede. If a good feeding and keeping quality of yellow turnip is desired, too much soluble phosphate should not be used, the application of nitrogenous manure should be restricted—as large quantities retard the ripening and induce a coarse watery bulb—and if the soil is good, the distance between the plants should be kept rather small than large.

SOWING MANGELS.

The mangel-wurzel, known more commonly as mangel, also as mangold, is embraced in the general term of "root crops." It belongs, however, to a race of plants quite distinct from the *Cruciferæ*, to which turnips and cabbages belong. The mangel cultivated on farms is the *Beta vulgaris* of the natural order *Chenopodiaceæ*. It is really a cultivated form of the wild sea-shore beet found in countries of the temperate zone. It was first grown as a garden plant, and it is understood that the field mangel was raised by crossing the red and white varieties of garden beet, the great development of root and distinctive features being obtained by persistent careful cultivation and selection.

Professor Wilson states that the mangel was introduced into this country in 1786 by Thomas Booth Parkins, who obtained the seed in Metz. It is cultivated largely in France and Germany for the production of sugar. It is grown in the United Kingdom solely as food for stock.

Climate for Mangels.—Mangels require different climatic conditions from those most favourable to turnips. Dry, hot summers are best suited to mangels. They thrive admirably, and yield a great weight per acre, in the southern counties

of England and in the warmest parts of Ireland; but even in the best favoured districts of Scotland they are unreliable, and north of the Tweed are grown only to a very limited extent. Mangels stand drought much better than turnips.

Soils for Mangels.—Mangels need good soils. Thin poor soils, and the bleak, cold, high-lying lands upon which turnips luxuriate, are quite unsuited for mangels. Rich alluvial loams in high condition and well cultivated are best adapted for mangels, and they also grow well on strong lands in a warm climate, if these are carefully prepared and liberally manured. For the strong lands of the south of England they are better suited than turnips.

Cultivation for Mangels.—The preparation of land for mangels is in the main similar to that for turnips. And having already discussed so fully the various methods of autumn and spring tilling, cleaning, and manuring land for turnips, it will be unnecessary to do more here than point out wherein these practices should be varied to suit the mangel crop.

Autumn Tillage.—The great object to be aimed at in preparing land for mangels is to have it cleaned, dunged, and deeply ploughed in autumn. When the land is stiff these should be done as early in autumn as possible, generally before the end of October. Deep autumn ploughing is especially beneficial for mangels, and where the subsoil is inclined to form into a "pan," it should be broken up by subsoil ploughing.

It is a good plan, after the land has been thoroughly cleaned and deeply ploughed in September or October, to at once open drills, spread the dung, and cover in the drills just as at seed-time for turnips. Some recommend that before spreading the dung a drill-grubber should be run along to loosen the bottom of the drills. In these ridges the land lies throughout the winter, admirably exposed to the disintegrating influences of the season, and is found easily prepared for the seed next spring.

Spring Tillage.—When the land has been cleaned, ploughed, and dunged in drills in autumn, as just described, little has to be done in the way of tillage in spring. A light harrow is drawn along the drills (not across them), the drills are again set up by the drill-plough, and the seed thereupon sown. Such artificial manure as is to be given may be sown broadcast either before the harrowing or before the setting up of the drills.

When the dung has been simply ploughed in with an ordinary furrow in autumn, the land has to be grubbed and harrowed in spring just sufficiently to secure as fine a tilth as possible. Deep spring ploughing when the land has been dunged in autumn is not to be commended.

It often happens, most generally in fact, that a sufficient supply of dung is not available till well into the winter or early in spring. In this case the land is cleaned in the autumn and left in a strong furrow till early spring, when it is grubbed or ploughed, or both, then harrowed, drills opened—if the raised drill system is pursued—the dung spread, artificial manure sown, the drills closed, and the seed sown.

Strong land should be stirred as little as possible in spring. Mangels, like turnips, delight in a fine moist seed-bed, and it is difficult to obtain this with much stirring of strong land late in spring.

Drills and Flat Rows.—Mangels are sown both in rows on the flat and in raised drills. The latter is the better plan, as it affords greater facilities for the after tillage and cleaning of the land. The rows on the flat usually vary from 18 to 25 inches wide, and the raised drills from 25 to 28 inches.

Mangel Seed.—The seed of mangels is encased in a rough woody capsule which makes germination very slow, unless special means are taken to hasten it. For this purpose the seed is steeped, for from 12 to 36 hours, before sowing—by some in warm water, by others in cold water, and by others again in liquid manure. If warm water is used, 12 to 14 hours should be sufficient. The seeds, when removed from the steep, are spread on a wooden floor, or on canvas cloth or sieve, and allowed to attain such a state of dryness as will prevent adhesion. In some cases the saturated seed is coated with a quantity of

finely powdered charcoal, which is freely mixed with it.

The seed is then sown either by the flat-row drill or raised-drill machine, as the case may be. The peculiarities of the mangel seed necessitate the attachment of specially devised seed-boxes. Water or ashes may be sown along with the mangel seed, as in the case of turnips.

Quantity of Seed.—The quantity of mangel seed sown per acre is usually about 6 or 7 lb.

Time of Sowing.—Mangels have to be sown earlier than turnips. April is, as a rule, the best month for mangel sowing, but portions of the crop are usually sown earlier, sometimes even as early as February. When, owing to a crop of winter rye or some other catch crop occupying the land, or when, from some other cause, it cannot be prepared sooner, sowing may be done in May. After the middle of that month it would be very risky.

Manures for Mangels.

Dependency on Manure.—Mangels require, and will under favourable conditions repay, liberal manuring. It would be useless to attempt to grow them upon scanty fare.

They produce an extraordinary yield in a comparatively short space of time. To enable them to realise their full capabilities in this respect, an ample supply of the kinds of plant-food best suited to them must be furnished in a readily available condition. And the farmer must discriminate as to the kinds of plant-food to be supplied.

Ingredients absorbed by Mangels.—The following table, compiled from that on page 62, Divisional vol. i., shows the quantities of nitrogen, potash, and phosphoric acid—the three chief manurial elements—taken out of the soil by a crop of mangels weighing 22 tons of roots per acre:—

	Roots. lb.	Leaves. lb.	Total. lb. per acre.
Nitrogen . .	96	51	147
Potash . .	222.8	77.9	300.7
Phosphoric acid	36.4	16.5	52.9

Elements of Manure for Mangels.—These figures, compared with the corresponding analyses of a crop of turnips, show at a glance that the manurial wants of the mangel differ considerably from those of the turnip crop. Phosphates are essential for both, but do not by themselves exercise such a marked effect on mangels as on turnips. On the other hand, nitrogen, so little required for turnips, must be freely given to mangels. Then mangels will turn heavy dressings of good farmyard dung to better account than turnips can, while the palate of the mangel would seem to delight in having its food seasoned with a substantial pinch of common salt.

Phosphates for Mangels.—The exhaustive series of experiments with various manures for mangels conducted at Rothamsted have shown that while superphosphate is essential in a complete manure for mangels, it gives but a poor return in this crop unless accompanied by a liberal dressing of nitrogenous manure. The following table shows the small effect of superphosphate, as also of mixtures of mineral manures, upon mangels:—

Average for eight years, 1876-83.

	Per acre. tons.	cwt.
No manure	4	9
3½ cwt. superphosphate per acre	5	2
3½ cwt. super., 500 lb. sulphate of potash	4	10
3½ cwt. super., 500 lb. sulphate of potash, 200 lb. common salt, and 200 lb. sulphate of magnesia . . .	5	14

In these plots the mangels were grown year after year and removed from the land. Upon this impoverished soil the mineral manures alone were unable to appreciably raise the crop above the yield on the plot which had no manure of any kind for eight years.

But in conjunction with other manures a moderate dressing of superphosphate was found to be profitable in these experiments, as it has certainly been in ordinary farm practice. The truth of this remark will be shown clearly when we come to speak of the effect of "mixed manures" for mangels.

Nitrogen for Mangels.—The influence of nitrogenous manures upon mangels is quite wonderful. The following shows the results obtained in eight years' continuous cropping with mangels at Rothamsted:—

Average for eight years, 1876-83.

	Per acre. tons.	cwt.
No manure	4	9
550 lb. nitrate of soda, equal to 86 lb. nitrogen	13	17
400 ammonia salts, equal to 86 lb. nitrogen	7	7
Do. and rape-cake, equal to 184 lb. of nitrogen	11	7
Rape-cake, equal to 98 lb. nitrogen	11	6

This result of an average of 13 tons 17 cwt. of mangel roots for eight years from a dressing of nitrate of soda alone is certainly very remarkable, all the more so when the exhausted condition of the soil is kept in view. In the first year of the trial, when the land may be supposed to have been in an average condition of general fertility, nitrate of soda alone raised the yield from 6 tons 10 cwt. with no manure to no less than 20 tons 13 cwt. per acre. It is further remarkable, as showing the importance of readily available nitrogen for mangels, that even where a heavy dressing of farmyard dung had been spread, the addition of nitrate of soda gave a marked increase in the crop. This result will be shown under the heading of "Mixed Manures for Mangels."

A point of striking importance brought out here—and quite in keeping with practical experience—is the fact that the more slowly acting forms of nitrogenous manures have not given such a satisfactory yield of mangels as the quickly acting nitrate of soda.

Salts of ammonia, for instance, which yield up their nitrogen more slowly than nitrate of soda, have throughout the Rothamsted experiments—by themselves and in conjunction with other manures—had a much weaker effect upon mangels than the nitrate of soda. It will be noticed presently that the best results from ammonia salts were obtained when the dressing of artificial manures included a liberal supply of potash.

Similar remarks would apply to rape-cake. By itself or in conjunction with superphosphate it acted slowly, but with plenty of available potash present it gave as good results as did nitrate of soda.

The lesson which the practical farmer would perhaps draw from these results is that along with a liberal dressing of mixed manure, including superphosphate and potash, the slower forms of nitrogenous manure, such as ammonia salts or rape-cake, might be used with good effect, but that when the crop has to depend upon what is already in the soil for much of its food, especially potash, the more readily active form of nitrate of soda should be selected for mangels.

Potash for Mangels.—The results obtained by the application of potash for mangels at Rothamsted have been somewhat erratic. Potash is, of course, of no use alone. As a constituent of a mineral dressing it was of little or no account. With the quickly acting nitrogen in nitrate of soda, it had only a slight effect. With the more slowly acting forms of nitrogenous manures, ammonia salts and rape-cake, it exercised a marked influence.

Dung for Mangels.—A substantial dressing of farmyard dung would seem to be even more desirable for mangels than for turnips. From dung, as from all suitable manures, under favourable circumstances, the former certainly give a much larger production per acre than the latter. The following table shows the marked influence of dung upon the mangel crop in the Rothamsted experiments:—

Average of eight years, 1876-83.

	Per acre. tons.	cwt.
No manure	4	9
14 tons dung	15	10
550 lb. nitrate of soda	13	17
3½ cwt. superphosphate	5	2

It has been found in practice that to produce the maximum yields of mangels a liberal dressing of dung, along with other manures, is quite essential. Yet it is important to observe that, as will be shown presently, wonderfully large yields were obtained at Rothamsted from artificial manures alone.

Salt for Mangels.—It is not in the least surprising that the application of common salt has been found in general farm practice to substantially increase the yield of mangels. The plant, we have seen, is indigenous to the sea-coast, and its ash is found to contain from 25 to

50 per cent of common salt. The late Dr A. Voelcker applied salt to mangels on deep sandy soil, and obtained an increase of 2 tons 6 cwt. per acre from 3 cwt. of salt; 5 tons 11 cwt. from 5 cwt. salt; and 4 tons 1 cwt. from 7 cwt. salt. Sir James Caird has stated that a liberal dressing of salt, about 5 cwt. per acre, may increase the produce of mangels by 10 tons per acre.

In the series of Rothamsted experiments already referred to, the application of salt, along with other artificial manures, increased the yield in all cases. In some special investigations into the use of salt as a manure, Sir John Bennet Lawes and Dr Gilbert have obtained results unfavourable to salt. Indeed, Sir John states that in his special trials the salt seemed to check the growth of mangels, the produce of which, without salt, was 21 tons 2 cwt.; with 5 cwt. salt, 20 tons 10 cwt., and with 10 cwt. salt, 18 tons per acre.

These results at Rothamsted indicate that the application of salt is not desirable in all circumstances. Yet it is well established in farm practice that a moderate dressing of from 2 to 5 cwt. of salt will, as a rule, be profitable.

Mixed Manures.—Having noticed briefly the effects of the chief manurial elements by themselves, we shall now glance at the results obtained from mixed dressings. The results of the Rothamsted experiments on mangels in the eight successive years 1876-1883, may be conveniently shown in the following table:—

Yearly Dressing. Per acre.	Average of Bulbs for eight years. Per acre. tons.	cwt.
No manure	4	9
3½ cwt. superphosphate	5	2
550 lb. nitrate of soda	13	17
400 lb. ammonium salts	7	7
2000 lb. rape-cake and 400 lb. ammonium salts	11	7
2000 lb. rape-cake	11	6
14 tons dung	15	10
14 tons dung 550 lb. nitrate of soda, equal to 86 lb. nitrogen	21	9
14 tons dung 400 lb. ammonium salts, equal to 86 lb. of nitrogen	22	6
14 tons dung 2000 lb. rape-cake 400 lb. ammonium salts	25	1
14 tons dung 2000 lb. rape-cake	22	8
14 tons dung 3½ cwt. superphosphate	15	13
14 tons dung 3½ cwt. superphosphate 550 lb. nitrate of soda	23	10
14 tons dung 3½ cwt. superphosphate 400 lb. ammonium salts	22	1
14 tons dung 3½ cwt. superphosphate 2000 lb. rape-cake 400 lb. ammonium salts	24	13
14 tons dung 3½ cwt. superphbosphate 2000 lb. rape-cake	22	17
3½ cwt. superphosphate 550 lb. nitrate of soda	16	18
3½ cwt. superphosphate 400 lb. ammonium salts	9	10
3½ cwt. superphosphate 2000 lb. rape-cake 400 lb. ammonium salts	12	8
3½ cwt. superphosphate 2000 lb. rape-cake	12	17
3½ cwt. superphosphate 500 lb. sulphate of potass	4	10
3½ cwt. superphosphate 500 lb. sulphate of potass 550 lb. nitrate of soda	17	9
3½ cwt. superphosphate 500 lb. sulphate of potass 400 lb. ammonium salts	14	15
3½ cwt. superphosphate 500 lb. sulphate of potass 2000 lb. rape-cake 400 lb. ammonium salts	22	10
3½ cwt. superphosphate 500 lb. sulphate of potass 2200 lb. rape-cake	17	14
Mineral manures, consisting of 3½ cwt. superphosphate, 500 lb. sulphate of potass, 200 lb. chloride of sodium (common salt), and 200 lb. sulphate of magnesia	5	14
Above mineral manures 550 lb. nitrate of soda	19	10
Above mineral manures 400 lb. ammonium salts	16	1
Above mineral manures 2000 lb. rape-cake 400 lb. ammonium salts	25	14
Above mineral manures 2000 lb. rape-cake	19	13

These results tabulated as above will repay careful consideration.

Conclusions. — The principal conclusions which this consideration will point to are:—

1. *In regard to Dung and Nitrates.*

That even with a liberal dressing of dung a further supply of nitrogen, in the form of artificial manure, gives a large increase in the crop.

That the largest dressing of nitrogenous manure gave the heaviest crop.

That with dung the different forms of nitrogenous manures tried, nitrate of soda, ammonium salts, and rape-cake, are nearly equal in efficacy.

2. *Dung and Superphosphates.*

That the addition of superphosphates to dung gave hardly any increase in the crop.

3. *Dung, Superphosphates, and Nitrates.*

That with dung, and quickly acting nitrogenous manure in the form of nitrate of soda, the addition of superphosphate gave a moderate increase in the crop, fully 2 tons per acre, on the average for the eight years.

That with dung, and the more slowly acting forms of nitrogenous manures, such as ammonium salts and rape-cake, the addition of superphosphate had very little influence on the crop.

4. *Superphosphate and Nitrates.*

That a mixture of nitrogenous manures and superphosphate produced more than double the yield from superphosphate alone, and from 1 to 3 tons more than the yield from nitrogenous manures alone.

That the increase from the addition of superphosphate was largest with the quickly acting nitrogenous manure in the form of nitrate of soda.

5. *Superphosphate and Potash.*

That the addition of potash to superphosphate produced no increase, but rather the reverse on the crop.

6. *Superphosphates, Nitrates, and Potash.*

That the addition of potash to the mixtures of nitrogenous manures and superphosphates produced a remarkable increase in the crop.

That this increase is greatest with the slowly acting nitrogenous manures — greatest of all in the plot which had most nitrates in the form of ammonium salts and rape-cake.

That the addition of potash to the ammonium salts, rape-cake, and superphosphates increased the yield by from close on 5 to over 10 tons per acre, as compared with an increase of only about half a ton on the plot which received superphosphates and nitrate of soda.

That the less dependency of the nitrate of soda plot upon applied phosphates and potash would seem to be due to the greater power which the quickly acting nitrate of soda (as compared with the more slowly acting nitrogenous manure) exert upon the capabilities of the crop to ransack the soil for the phosphoric acid and potash it already contains. This conclusion would support the general opinion among practical farmers, that nitrate of soda is not only itself a valuable source of plant-food, but possesses the additional attributes of a stimulant, enabling the crops to utilise more largely the supplies of other elements of plant-food which exist in the soil.

7. *Mixed Mineral Manure and Nitrates.*

That a mixture of mineral manures, consisting of superphosphate, potash, common salt, and sulphate of magnesia, had by itself very little influence upon the mangel crop.

That the addition of nitrogenous manure to this mineral mixture at once raised the crop to, in several cases, nearly the level of the yield from dung and nitrogenous manures.

That the highest average over the entire series was obtained from mineral manures and the heaviest dressing of artificial nitrogenous manure, in the shape of ammonium salts and rape-cake, exceeding the dung, ammonium salts, and rape-cake by an average of 13 cwt. per acre over the eight years.

That dung and ammonium salts beat mineral manures and ammonium salts by 6 tons 5 cwt. per acre.

That dung and nitrate of soda beat mineral manures and nitrate of soda by about 2 tons per acre.

That nitrate of soda is thus a more

suitable form of nitrogen to accompany mineral manures than ammonium salts.

8. *Common Salt.*

That with all kinds of nitrogenous manures the addition of common salt seemed to increase the yield—the increase from common salt and sulphate of magnesia being from about 1½ to 3 tons per acre.

Farmers must think for themselves.—It cannot be doubted that from experiments conducted by others—such as these just described—farmers may derive much information that will be useful to them. Yet conclusions which may be thoroughly sound in regard to one set of circumstances cannot be said to have a general, or even a very wide application. So great is the variation in soil, climate, and system of cropping throughout the country, that each farmer must think for himself as to the particular dressing of manure that will be best adapted for his own special circumstances. He must study the climate, the nature of the soil, its condition as to fertility, abundance or deficiency of any of the essential ingredients of plant-food. Careful observation in this way, aided by test experiments on his own farm, and by a consideration of experiments conducted by others, will enable him to pursue such a system of manuring as may be expected to give satisfactory results.

Useful Dressings.—In general practice farmyard manure is almost always applied. To obtain a maximum crop, and yet maintain the land in a high state of fertility, a liberal allowance of dung may be regarded as essential.

Still it has been shown in the Rothamsted experiments that in certain circumstances a mixture of artificial manures, consisting of from 3 to 4 cwt. of superphosphate per acre, 5 cwt. of sulphate of potash, 2 to 3 cwt. of common salt, and 4 or 5 cwt. of nitrate of soda, and perhaps a little rape-cake, might produce a fairly satisfactory crop of mangels without any farmyard manure.

A heavier dressing of dung may with advantage be given to mangels than to turnips. From 12 to 16 tons of good dung are often applied with good results. Along with this a liberal allowance of artificial manure would be from 2 to 3½ cwt. of superphosphate, 2 or 3 cwt. of common salt, and 2 to 3 cwt. nitrate of soda or sulphate of ammonia. In many cases even larger quantities of artificial manures are applied; but with land in good average condition as to fertility these doses should as a rule be sufficient.

With a full allowance of dung there will seldom be much necessity for the application of special potash manure. If there is any reason, however, to suspect that there is a deficiency of potash in the soil, from 1 cwt. to 2 cwt. of kainit per acre should be applied.

As to whether it should be nitrate of soda or sulphate of ammonia which should be used along with the dung, the farmer must think for himself. He will especially consider the market price of the two commodities at the time, and buy whichever happens to be the cheaper. See what is said as to nitrate of soda and sulphate of ammonia at page 107, Divisional vol. iii. In a rainy climate and wet seasons sulphate of ammonia will most likely give better results than nitrate of soda.

The condition of the dung as to rottenness should also be taken into account in deciding whether to sow nitrate of soda or sulphate of ammonia. In well-rotted dung there is more readily available nitrogen than in fresh dung. With fresh dung, therefore, nitrate of soda would as a rule be preferable to sulphate of ammonia.

Application of Manure for Mangels.

Read what is said in the special chapter on "Manures and Manuring," as to the general principles to be observed in applying the various manures to land, pp. 126-135, Divisional vol. iii.

Dung.—If dung is available it should be applied in the autumn, and ploughed down or spread in drills, and covered in. If it cannot be applied in the autumn or winter, and if the mangels are to be sown in rows on the flat surface, the dung should be spread and ploughed in as early as possible in the spring. Where the mangels are to be sown in raised drills, and the dung cannot be applied till spring, it is spread in the bottom of the drills at sowing-time, as in the case of turnips—carted out and spread as described for turnips.

Artificial Manures. — Perhaps the most general plan is to sow these by the hand or machine in the drill or row at the time of sowing the seed, as for turnips. As a rule, however, it will be found advantageous to reserve the whole or greater part of the nitrogenous manure, especially if it happen to be nitrate of soda, and apply it as a top-dressing some time in July. The allowance of common salt is also by many held back till July, when some careful farmers apply a mixture of from 1½ to 2 cwt. of nitrate of soda, and 2 to 4 cwt. of common salt in two sowings.

There is no denying the advantage of such a top-dressing for mangels. It has been well established in extensive practice. By holding back the nitrate of soda till the plants are ready to make use of its nitrates, loss by washing into the subsoil and drains is avoided.

Theoretically, one would expect that the slower acting sulphate of ammonia should give better results by being applied at the time of sowing. Nevertheless, some farmers prefer to use it as a top-dressing—prefer it to nitrate of soda for this purpose also. These are points as to which hard-and-fast lines cannot in all cases be followed.

Thinning and After Cultivation.

Preliminary Cleaning. — Mangel plants are slower in growth at the very outset than are those of turnips. To keep down weeds, therefore, it may be necessary to horse or hand hoe the rows or drills before the plants are ready for thinning. This preliminary hand-hoeing need be resorted to only in narrow rows on the flat, or where weeds are encroaching injuriously upon the plants. The horse-hoe or drill-scarifier will suffice, as a rule, in raised drills.

Thinning. — As soon as the plants show a fairly strong leaf, they should be thinned and hand-hoed as in the case of turnips. From 12 to 16 inches are common intervals between the plants. The narrower the drills, the greater should be the interval between the plants in the rows.

As with turnips, it has been found (by the late Dr A. Voelcker and others) that mangels of medium size usually contain more solid nutritious matter than mangels of excessive size. And by moderate, rather than large, intervals between the plants, the maximum yields of good food per acre are likely to be obtained.

After Hoeing. — The treatment of mangels after thinning is, in regard to hoeing by hand and horse-power, very similar to that of turnips. The horse-hoe or scarifier should be kept at work as long as the leaves of the roots will permit.

Transplanting Mangels.—The young mangel plant may be successfully transplanted. Blanks in the rows should be filled up by transplanting. This should be done with care, so that the tap-root may be dibbled right down into the soil. Unless the weather is showery at the time or the soil moist, the transplanted plants should receive a spray of water.

Very heavy mangels have been grown experimentally from plants raised in a seed-bed (sown in January), and planted out in February. How far this system could, with advantage, be extended into farm practice is uncertain.

Injuring Mangel Plants. — Mangels are peculiarly liable to suffer from injuries to the leaves of the plants. Cuts or bruises to the leaves, even if inflicted when the plants are very young, do not heal up as would be the case in turnips — they remain as open, "bleeding" sores, robbing the plant of not a little of its life-juice, and rendering it liable to ready attacks of frost and decay. In the thinning of mangels, therefore, the plants should be guarded with the greatest care.

Varieties of Mangels.

There are many sub-varieties of mangels in use. The principal sorts are the long red, red globe, and orange and yellow globes. The last two are the hardiest, of excellent quality, with good keeping properties, and suitable to most soils in which mangels grow satisfactorily. The long red mangel is extensively grown on heavy soils, and produces great crops in favourable circumstances. They stand high out of the ground, and are therefore exposed to damage from early frosts. The red globe is better suited for lighter soils.

Produce of Mangels.—This varies greatly—from 12 to over 50 tons per acre.

From 30 to 35 tons are considered good crops in moderately favourable years.

Diseases and Insect Attacks.—The mangel suffers less than turnips from fungoid attacks. The mangel maggot often injures the crop by feeding on the leaves. See the chapter on insect attacks.

KOHL-RABI, CARROTS, AND PARSNIPS.

These subsidiary varieties of root crops are well worthy of the attention of farmers. Often by cultivating patches of these the revenue of the farm may be appreciably increased.

KOHL-RABI.

Properly speaking, the kohl-rabi should not be classed with the root crops. Its bulb is formed by an enlargement of the stem or stalk, and it is thus grown for its stem and not for its root. Nevertheless it falls into the rotation with the root crops, and is cultivated for the same purposes, namely, to provide winter food for farm stock.

Kohl-rabi was cultivated in this country as far back as 1734, but it was not generally known till about 1837.

Advantages of Kohl-rabi.—Kohl-rabi undoubtedly possesses high merits as a field crop, and it is surprising that in England especially its cultivation has not extended much more widely than has been the case. In Scotland, and other parts well suited for turnips, there there may be little necessity for it, but on the stiff clay and soft fen lands of England, which are well suited for kohl-rabi and badly fitted for turnips, it ought to be grown more largely.

The advantages of kohl-rabi as a field crop are thus forcibly stated by Professor Wrightson :[1]—

"It is subject to no diseases, and few insect attacks. Like the turnip, the young plants are liable to the depredations of the turnip flea-beetle, but in a less degree to swedes and turnips. It thrives on two classes of soils upon which turnip cultivation cannot be very successfully carried out—namely, upon the stiffest classes of clays, and the fen-lands of East Anglia. It possesses great powers of resistance to drought, and in fact thrives best in hot and dry seasons. It is exceedingly hardy, and resists frosts successfully. The crop may therefore be left over till the spring of the year. The leaves are of the same quality for feeding purposes as the stems, and resemble rape or kale leaves in nutrient properties. It is well suited for cow-feeding, as it does not impart an unpleasant flavour to milk. It is well adapted for sheep-feeding on the ground, because the bulb being supported upon a footstalk it can all be eaten without the waste which is inevitable when turnips are fed. It is an excellent feed for ewes and lambs in the spring, as it supplies leafy herbage as well as more solid food."

Uncertain Crop.—Perhaps the influence which has been most instrumental in restricting the cultivation of kohl-rabi is the belief that it is rather uncertain in its growth—liable to grow to a mass of leaves with insufficient development of bulb. This drawback is being gradually removed by the raising of improved varieties which are more reliable in their development.

Soil for Kohl-rabi.—Kohl-rabi grows well on all soils adapted to swedes, and may also, as we have seen, be cultivated with success on stiff clays and fen lands.

Tillage and Manuring.—These should be very similar to what are best suited for mangels—deep autumn tillage and dunging, grubbing or cultivating in spring, with a liberal dressing of nitrogenous manures.

Planting or Sowing.—Kohl-rabi may be sown either on the flat or in raised drills exactly like turnips; or the plants may be raised in seed-beds, and transplanted into rows 25 to 27 inches apart, with from 10 to 16 inches between

[1] *Fallow and Fodder Crops*, 190.

the plants. The seed should be sown in the seed-bed fully two months before the time for transplanting, as the plants should be about 8 inches high before being transplanted. From 10 ounces to 1 lb. of seed sown thinly in rows a foot apart, in a well-prepared seed-bed, should produce sufficient plants to cover one acre.

Some particularly careful farmers always raise a few kohl-rabi plants with which to fill up blanks and odd corners in the root field.

Time for Sowing.—The seed may be sown in the drills in April. Transplanting may take place from the first of May till the middle of August.

Thinning and Hoeing.—When sown directly in the field the plants are thinned like turnips, with wider intervals between the plants—from 10 to 15 inches. The after tillage and hand-hoeing is exactly the same as for other root crops.

Produce.—From 20 to 25 tons per acre are common crops. Occasionally the produce reaches from 30 to 35 tons or more.

Varieties.—The varieties of kohl-rabi most largely in use are the green round, green oblong, purple round, and purple oblong.

CARROTS.

Carrots (*Daucus carota*, Natural Order *Umbelliferæ*) are more of a garden crop than a crop for general field culture. Yet on most farms with suitable soil a small patch of them may be grown with advantage. Carrots are, in limited quantity, excellent food for horses; and with capital results the carrot-tops may be used as food for cows in milk.

Carrot-tops as Food for Stock.—The high feeding value of carrot-tops is not generally known or acknowledged among farmers, for the tops are, as a rule, left on the ground, just as in the case of turnip-tops. Writing on this subject, Mr John Speir, Newton Farm, who grows carrots extensively for the Glasgow market, says:[1]—

"Where carrots are grown the carrot-leaves form an excellent class of food for any kind of farm stock. They are relished extremely by both sheep and cattle, dairy cows doing particularly well on them. A good few tons of leaves are yielded by each acre of well-grown carrots, and a ton of carrot-leaves appears to me to be more valuable than the same weight of turnips.

"To dairy cows I have fed carrot-leaves regularly for over a dozen years, and the longer I use them the more I prize them. I have repeatedly been laughed at for the opinions I held regarding the value of carrot-leaves, by those who had little or no experience of their use, my friends saying they were not worth the cartage, and that I was impoverishing the land by taking them to the cows. I grant I was decreasing the fertility of the land, but I was increasing my milk production, and there was no greater occasion why these carrot-leaves should not first pass through the bodies of animals before being applied to the land, than should a second crop of hay or clover, diseased potatoes, or for that matter of it, any palatable farm crop, be it a first or second one.

"**Analysis.**—In support of this view are appended, for the sake of comparison, the analyses of the digestible constituents of a few similar plants, as given by Professor Stewart.

	Carrot-leaves.	Cabbage.	Turnips.	Potatoes.	Pasture Grass.
Water . . .	82.2	84.7	92.	75.	80.
Albuminoids . . .	2.2	1.8	1.1	2.1	2.5
Carbohydrates . . .	7.0	8.2	6.1	21.8	9.2
Fat	.5	.4	.1	.2	.4

"From this it will be seen that carrot-leaves compare favourably with any of the other articles of food, and although considerable latitude be allowed for variation in the analyses of the samples here given, there is still room enough for much to be said in favour of carrot-leaves. If we allow the stock themselves to be the judges, the point will be easily settled, as the carrot-leaves will be taken

[1] *Farming World Year-Book*, 1889, 124.

in preference to almost any of the other foods named.

"I may here mention in support of this view that it is well known that hares and rabbits travel long distances to feed on carrot-leaves, and they are as dainty in regard to their food as any animals on the farm. In my own case I have for very many years used the produce of from 15 to 20 acres annually with the most satisfactory results, while throughout the country generally it is only the few here and there who do use them anything like extensively. Those farmers who allow them to lie and rot would be considering they were extremely careless if they allowed even a tithe of the same weight of turnips to lie rotting in the fields, while they pay no attention to what is an equally if not more valuable crop, although at the same time a more perishable one.

"**Storing.**—This last, in fact, is one of the greatest difficulties in using a large breadth of carrot-leaves, yet by judicious management in consumption, the cold season of the year during which they come into use, and by keeping them in very small heaps in the field, their consumption may extend over a period of from one to two months, according to the area to be consumed and the number of stock to consume them."

Soil for Carrots.—Carrots, having a strong deep root, require soil of considerable depth. A good sandy loam is best adapted for the crop. We have seen excellent crops of carrots on well-manured land with a mossy tendency.

Tillage and Manuring.—The land must be deeply cultivated in the autumn. If the subsoil is stiff, it should be loosened by the subsoiler. Autumn dunging is generally preferred, but where this is not convenient the dunging may be done in spring, as for other root crops. Carrots will take as heavy dunging as any of the root crops. The dressing of artificial manure applied may consist of from 2 to 3 cwt. superphosphate and 1 to 2 cwt. of nitrate of soda, sown as a top-dressing just after singling, or in two portions, one before and the other after singling.

If the land has been dunged and well tilled in the autumn, little cultivation in spring will suffice. A fine tilth and a loose range for the searching root are very desirable. Yet harm may be done by overworking the land in spring.

Cleaning for Carrots.—It is specially important to have the land for carrots as thoroughly cleaned as possible. The leaves of the carrot are small, compared with those of mangels and turnips, and the growth of weeds is thus encouraged by the large amount of space which remains uncovered.

Sowing Carrots.—Carrots are usually sown about the end of March and beginning of April. They may be sown in rows on the flat, from 15 to 18 inches apart, or in raised drills from 27 to 30 inches wide. In the latter case, two rows of seed are sown on the one drill. The wide raised drill is preferred by many, because of the greater facility it affords for cultivating and cleaning the land.

Preparing Carrot Seed.—About 6 lb. of seed will sow an acre. The hairy covering of the seeds makes their separation rather difficult, and to overcome this difficulty it is a good plan to mix the seed with fine sand, perhaps at the rate of 1½ to 2 bushels of sand per acre. The seed and sand should be thoroughly intermixed by rubbing with the hands; moisten the mixture with water, spread it out on a dry floor, turn daily, sprinkle with water if it become dry, and when it has lain from a week to ten days in this form, it should be sown, just before the seed germinates. When this preparatory process is gone through with proper care, the plants will come up more quickly than if sown without the week or ten days of incubation. This is an important point, because the carrot plants are so tiny in their earliest stages that, when sown on the flat surface, they are liable to be covered and overcome by weeds.

In many cases a little oats, barley, or turnip seed is sown along with the carrot seed for the purpose of indicating the rows, and thus enabling the hoe to be used with freedom before the carrot plants are very clearly visible.

It is unsafe to use old carrot seed. It should be the produce of the previous year's crop.

Thinning Carrots. — The plants should be thinned when the leaves are

from 1 to 3 inches high. Intervals of from 4 to 8 inches, according to the variety grown, are left between the plants. When grown on raised drills, with two rows on each drill, the plants are singled so that they alternate rather than sit directly opposite or abreast in the two rows. Horse and hand hoeing should be pursued as with other root crops.

Carrots and Rye.—The late Professor Wilson described a practice followed by some enterprising Continental farmers, in which crops of rye and carrots are grown upon the same land, so as to overlap each other in rather an ingenious way. He said: "In the light-soil districts of Belgium and Holland, where carrots are cultivated to a far greater extent than with us, it is a common practice to grow them mixed with a crop of rye or flax. In the former case the rye is sown early in the autumn, so as to root well before the winter sets in, and thus come early to harvest the following year. In the spring the carrot seed is sown broadcast as late as the growth of the rye will admit of the harrows being used to cover the seed. This germinates and continues its growth until the rye is ready for cutting, which usually takes place about the second or third week in June. It is then mown with a cradled scythe, care being taken not to cut it so close as to injure the top of the root of the young carrot plants, which by this time have acquired a size about the thickness of one's finger. The field is cleared as quickly as possible of the stooks, the harrows are sent over the ground to disturb the surface, and to drag up the roots and stubble that are left, while the remaining weeds are carefully removed by the hand. The liquid-manure cart follows with a supply of rape-cake mixed up with 'purin,' and in a few days the young plants begin to show themselves again; and by the end of the autumn are in a condition to yield a weighty crop of roots, which, when forked up in the usual manner, leaves the land in excellent condition, both chemically and mechanically, for the succeeding crop of corn."

Varieties.—There are many varieties of carrots in use. The best known are James's Intermediate, the Altringham long red, white Belgian, large red, and short red.

Produce.—The produce in average seasons should reach from 12 to 20 tons per acre. It is sometimes more, often less.

Certain species of wire-worms and the carrot-louse (*Aphis dauci*) attack and damage the crop.

PARSNIPS.

The parsnip is the *Pastinaca sativa* of the same Natural Order as the carrot, *Umbelliferæ*. Indeed, the two plants are so very similar in their habits of growth that the remarks as to soil, tillage, and manuring for carrots may be held as applying also to parsnips.

Parsnips go still deeper into the soil than carrots, and grow to their best in a heavier loam than that which carrots specially delight in. In the south the parsnip seed—6 or 7 lb. per acre, with a little oat, barley, or turnip seed, as with carrots—may be sown as early as February.

Parsnips are usually grown in rows on the flat surface about 14 or 15 inches wide, and the plants are thinned to from 6 to 8 inches apart.

Among the varieties of parsnips most largely grown are the long-rooted parsnip, the Student, the long Jersey (or hollow crowned), large Guernsey, and Cattle parsnips.

Both parsnips and carrots are found growing wild as a weed in this country. No doubt the cultivated varieties have been raised from these.

It will be seen from analysis on page 266, Divisional vol. ii., that the parsnip is possessed of very high fattening properties.

FORAGE CROPS.

In pages 253-260, Divisional vol. iii., information is given as to the cultivation of forage crops which should be perused at this point. Note in particular the directions as to successional sowings of vetches and the sowing of the seed of cabbages, thousand-headed kale, and rape in the summer months.

SUMMER CULTURE OF CORN CROPS.

The corn and pulse crops require a share of the farmer's attention in the summer months, particularly in the earlier part of the season. By horse and hand hoeing, weeds are kept down and the land stirred, with much benefit to the crop. In many cases a moderate top-dressing of manure is applied with advantage, while, in wet seasons, the farmer must see that surface-water is not allowed to lie on any portion of his crops.

CULTURE OF BEANS.

Beans require a good deal of labour and attention in summer.

Beans in Raised Drills.—The spring work in connection with bean-sowing was completed (see p. 205, Divisional vol. iii.) by the harrowing of the drills about a fortnight after the seed had been sown.

Horse-hoeing.—As soon as the young plants growing on raised drills have attained 2 or 3 inches in height, the common drill-grubber or scuffler should remove the weeds that have appeared between the drills in the interval of time since the drill-harrowing. The grubbing will also reduce the clods and loosen the soil generally.

Hand-hoeing.—The field-workers follow the scuffler with the hand-hoe, and remove the weeds growing around the plants, and displace clods that are seen to interfere with the plants. The workers should be careful in using the hoe amongst bean plants, which are very tender and easily cut and bruised.

After the plants have risen about 1 foot in height, which they will soon do in good growing weather, the blossom will begin to appear; and its appearance is with many the signal to finish the work amongst the crop. Time may be found to again drill-grub between the drills, and hoe the sides of the drills along the plants; but if not, the double mould-board plough should, as the last operation, set the earth up to the roots of the plants, to give them a firm footing on the top of the drill.

Rows on the Flat.—The summer culture of beans growing on flat ground in rows is the same, in as far as scuffling, hoeing, and drill-grubbing the ground are concerned, as on the raised drill. Almost the only difference is that the land is not set up with the double mould-board plough.

No Harbour to Weeds.—No amount of horse and hand hoeing should be grudged that may be necessary to make and keep the land free from weeds. It should be remembered that one of the objects in having beans sown in drills is to have the land well worked and cleaned.

Broadcast.—When beans are grown broadcast, no implement but the hand-hoe is of any avail in clearing the ground of weeds; and as hand-hoeing would require to be performed much oftener than time will allow, to keep the ground as clean as it should be, the consequence is that a crop of broadcast beans affords a harbour to weeds, unless growing weather pushes the bean plants forward to smother the weeds.

Cropping Beans.—After the bean plant has grown until all the pods are set, the practice of the garden indicates that, when the top of the plant is cut off in moist weather, at that period of its growth the crop will be sensibly increased. This is a probable result, it being a common observation that in moist weather the bean has a great tendency to grow in height long after the pods have ceased to form. As long as this tendency continues, the pods and beans do not enlarge; and the only mode of checking it is to cut off the top, when the vigour of the plants' growth will be solely devoted to the nourishment of the fruit.

CULTURE OF PEAS.

Although a common practice is to sow peas along with beans, yet, as they are also cultivated alone, it is necessary to bestow attention on them when so culti-

vated. When sown broadcast, the pea plant, growing quickly, especially in moist weather, soon overspreads the weeds growing along with it. But though it overspreads, it does not entirely destroy them. The consequence is, that the ground is left by the pea crop in a foul state.

When sown in rows, in every third furrow of the plough, or in raised drills, the ground is scuffled, hoed, and drill-grubbed, as are beans when sown in rows on the flat.

These operations require to be rapidly performed, the quick and straggling growth of pea-stems affording neither time nor room for dilatory work

CULTURE OF WHEAT

The amount of attention which the wheat fields demand in the summer months depends mainly upon the time they had been sown.

Autumn Wheat.—Autumn or winter sown wheat may be too far advanced in growth before the advent of summer to permit of any cultural work being given to it in that season. Such horse-hoeing or harrowing as it may require will therefore be performed in spring. The state of the autumn-sown wheat in summer depends on the weather in winter and spring, and the nature and condition of the soil upon which it was sown.

Over-luxuriance in Autumn Wheat.—Mild weather in winter will cause it to grow luxuriantly; and if the mildness continue till spring, the plants may, from over-luxuriance, lie down in spring, and become blanched and rotted at the roots. In the early part of winter, if the ground is dry, sheep may eat down luxuriant wheat to a considerable degree. Even if not folded on it, sheep will do much good to luxuriant wheat by trampling upon it for a while every day, and eating off the tops of the plants.

But the winter luxuriance is frequently checked, and even the plants destroyed, by severe frosts at night and bright sunshine during the day in March. Should the winter luxuriance continue till spring, sheep cannot then crop it uniformly, and should not be allowed to attempt it. If luxuriance only commenced in spring, sheep can restrain it then as well as in winter.

Cropping Rank Wheat.—The winter luxuriance can be restrained in spring only by mechanical means—by cutting off the tops with the scythe. This may be done safely until the plant puts forth the shoot-blade, perhaps as late as the end of April. Before commencing cropping with the scythe, some of the most forward plants should be opened to ascertain the position and length of the ear, which should not be touched. The leaves cut off lie on the ground to decay. The advantage of cropping wheat when over-luxuriant is, that rain will no longer hang upon it, and air and light will have access to the stem to strengthen and support it. The risk of lodging is thereby greatly lessened. Spring wheat rarely becomes too luxuriant in summer, and requires no expedient to check its growth.

Soil and Over-luxuriance.—Of the classes of soils which produce over-luxuriance, dry deep clay loam is most apt to do it in a mild autumn and winter; and thin clay land, upon a retentive wet subsoil, is most liable to destroy wheat in March. Even when showing no luxuriance, and the crop promising, yet by the injurious effects of March weather the plants may not only be sickly and scanty, but too late to tiller.

Fig. 364.—*Weed-hook.*
a Acute hook with 2 sharp edges.

Weeding.—The weeding of the cereal crops in summer where the land is foul is an indispensable work for their welfare. If the crop should be too far advanced to permit horse labour, the weeding must be done solely by the hand or with manual implements; if not, both manual and horse implements may be employed—that is, where the seed has been sown in drills. Among broadcast grain, weeding must be performed by the hand and with manual implements. An effective tool for this purpose is the simple weed-hook, fig. 364. It consists of an acute hook of iron, the two inner edges

of which are flattened and thinned to cut like a knife, and which are as far asunder at one end as to embrace the stem of succulent herbaceous plants which are destined to be cut down. The cutting-hook is attached to a socket, which takes in the end of a light wooden shaft about 4 feet in length, which is fastened to it with a nail or screw, the hook having such a bend as that its under surface shall rest upon the ground, while the worker uses the shaft in a standing position. A sharp spud with a cross-head handle is the best instrument for cutting weeds with strong stems —as docks, thistles—with a push.

The best way for field-workers to arrange themselves, when weeding broadcast corn, is for two to take one ridge, each clearing one-half of the ridge from the open furrow to the crown. On weeding amongst corn, the point of the weed-hook is insinuated between the stems of corn toward the weed to be cut, and on its stem being taken into the sharp cleft of the hook at the ground, it is easily severed by a slanting cut upwards towards the worker. The weeds, cut over, are left on the ground to decay; but no weed should be allowed to grow *beyond* the time of its flowering. Docks should be pulled up by the root and carried away and burned.

Hoeing Drilled Wheat. — Wheat sown in rows may be weeded with the hand-hoe, or with horse-hoes. The hand-hoe is used by field-workers, who each take one row between the drills. To prevent jostling, the worker in the centre of the band takes the lead in advance position, while the others follow on each side in echelon. Where drilled crops occupy much extent of ground, the ordinary number of hand-hoers are unable to clear the weeds before the crops advance too far to go amongst them. Hence the need of the more expeditious horse-hoe.

Horse-hoeing. — There are many forms of horse-hoes for cleaning the ground between the rows of corn. The improved kinds are light in construction, yet sufficiently durable, and do their work admirably, cleaning from six to a dozen rows at a time. One form is shown in fig. 365. The coulters used in these horse-hoes are of many different patterns, in some cases fixed upon one cross-bar, and in others upon two bars, the one in front of the other.

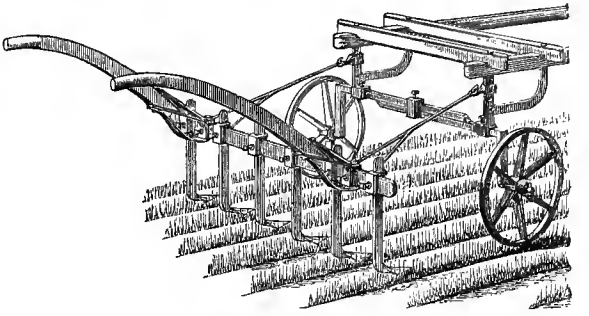


Fig. 365.—*Steerage horse-hoe.*

These hoes go over the ground quickly, and are easy work for one horse.

The horse-hoeing of corn should be intrusted to a careful man and a steady horse. A steady horse will not leave the row he walks in from end to end of the landing. A young horse is unsuited for this work. A careful man to steer the hoes is as requisite as a steady horse; otherwise the hoes may run through the rows of corn-plants, tearing them up as well as the weeds.

As already indicated, to wheat sown in the preceding autumn or winter this horse-hoeing has usually to be given in spring, that is, if given at all.

Top-dressing Wheat.—If the crop is not making satisfactory progress, or if it is considered desirable for any reason to top-dress wheat late in the season, this may be done during the month of May. Mild moist weather is most suitable for the process. At this late period of the season a dressing of nitrate of soda, perhaps from 1 to 2 cwt. per acre, would likely give the best result. Some would add 2 cwt. of superphosphate. It is considered a good plan to delay a portion of the more quickly acting manures to be sown as a top-dressing in this way. See pages 135-169 and 201, Divisional vol. iii.

Flowering Season. — The flowering season is critical for wheat, since a differ-

ence in the weather of June may affect the yield to upwards of 50 per cent. Should the weather be rainy and windy in the flowering season, the produce will inevitably be scanty. Rain alone, unless of long duration, does not affect the produce as much as strong wind, which seriously injures the side of the ear exposed to it. Showers and gentle breezes do no harm; but sunshine, heat, and calm are the best securities for a full crop.

CULTURE OF BARLEY.

Such weeding and hoeing as the barley may require is usually given as in the case of wheat.

Removing Charlock. — The barley crop is especially liable to be infested with charlock, *Sinapis arvensis* (sometimes known as "skeylock," "wrinch," or wild mustard). It is a most troublesome weed, and, if left to its freedom, would, in many cases, most seriously injure the crop. Formerly the only remedy was to pull up the charlock plants by the hand; but this process was too costly and tedious to be practicable upon large areas. At last, however, the genius of the inventor came to the aid of the farmer, and a machine (the "Koldmoos Weed Eradicator") is now made by which the weed may be expeditiously removed, or at least severely checked.

This machine consists of a revolving drum set on wheels, with an arrangement of comb-like teeth, protruding from and retiring into the drum during its revolution. When the charlock comes into full bloom, it is some inches higher than the braird, and the teeth of the machine grasps the heads of the plants, and either tears them up by the roots or detaches them from the stem. The crop thus obtains considerable if not complete relief, while the charlock is prevented from seeding.

Top-dressing Barley. — Barley may be top-dressed like wheat. From 1 to 2 cwt. of nitrate of soda and 2 cwt. superphosphate would be a good late dressing. (See pages 210-211, Divisional vol. iii.)

Barley is not much affected by the weather in the flowering season, since rain and strong wind seldom then come at the same time.

CULTURE OF OATS.

The weeding of oats is not often practised when the seed has been sown broadcast, except to remove docks or thistles. When the thistle flourishes amongst corn, it is extremely troublesome to reapers at harvest. This plant should not be cut down till it has attained 9 inches in height, otherwise it will spring from the root, and require another weeding; and by the time it has attained 9 or 10 inches, the oats will be about 1 foot high. In weeding oats in broadcast, the field-workers may be arranged in the manner described for wheat.

Charlock is also a troublesome weed amongst oats. It may be removed as described in the case of barley.

A light top-dressing of from 1 to 1½ cwt. nitrate of soda and 2 cwt. superphosphate per acre, is sometimes given to the oat crop early in May. (See page 214, Divisional vol. iii.)

Oats are as little affected by weather in the flowering season as is barley. Both are in flower about the same time, and the weather must be stormy for successive days to injure either.

CULTURE OF RYE.

Rye has become almost obselete as an ordinary corn crop in British husbandry. It is now chiefly confined to Northern Europe, on poor, loose, sandy soils which are not suited for other kinds of grain. In the south it is grown as a sort of forage or catch crop, to be consumed on the land by sheep.

Rye, sown in spring, runs through its courses rapidly, and comes early to maturity in summer. The straw thus attains a considerable height before the ordinary weeds make a formidable appearance, so that summer hoeing or weeding is seldom necessary.

CROSS-FERTILISATION OF GRAIN.

It may be useful to introduce here the following notes by Mr John Speir as to the cross-fertilisation of grain, with the view of obtaining improved varieties of renewed vigour:—

Degeneracy of Grain.—Most varieties of fixed types of plants appear to degenerate or become weakly after having been subjected, for a number of years, to the forcing influences of modern cultivation. Comparatively speaking, indeed, only a short time elapses between their introduction and the time when they commence to show signs of decay. With the grains this is in part averted by repeatedly and continuously using seed grown in some different locality, so that their rate of degeneration is slow in proportion to that of some other farm crops—potatoes, for instance.

As a rule, however, new varieties of grain, if otherwise good, are more vigorous in growth than most old ones, and in consequence their production is a matter of great importance to the arable farmer. The grains have not been improved to an equal extent with most other farm crops.

Mr Knight's Efforts.—Previous to the middle of the present century most of the new varieties of grain were natural crosses or sports, which were perpetuated and increased by selection. It appears that Mr Knight, a celebrated horticulturist who lived during the latter half of the last century, introduced a considerable number of new varieties of grain; but although he was aware how cross-breeding was done, it does not appear that he obtained any of the varieties he introduced by directly crossing them. His method of procedure was to grow a number of varieties together, in the hope that a favourable natural cross might be produced. In this way he was able to introduce several new varieties, which were of such a strong constitution that, during the years 1795 and 1796, when most grain in this country was blighted, the varieties thus obtained are said to have more or less escaped.

Mr Raynbird's Experiments.—In 1851 Mr Raynbird and Mr Maund showed ears of cross-bred wheats at the great International Exhibition held in London in that year. These are supposed to be the first direct cross-bred grains which were ever offered to the public; and although many of them were considered more as curiosities than anything else, still one of them attained considerable popularity as Raynbird's Hybrid in after-years.

Mr P. Shirreff's Experiments.—About this date Mr Patrick Shirreff of Haddington commenced his experiments in cross-breeding and selection. In the twenty years or so during which he persevered in the work, he succeeded in introducing several new varieties; but although he may be considered the first methodical cross-breeder of grain, he still says he was as successful in getting new varieties from mixtures by natural crossing as from those directly fertilised.

Recent Experiments.—About the year 1882 Mr Sharman, of the firm of Messrs James Carter & Sons, London, commenced experiments in the cross-breeding of wheats, which have been attended with a good deal of success. These experiments have been since carried on, and ten new varieties are offered to the public, most of which, as far as appearance of the grain is concerned, look well. All more or less differ in character, some having long straw, and some short. Others have slender straw, while many are stout; some are very early, while others ripen about the usual time. Messrs E. Webb & Sons, Wordsley, Stourbridge, are also carrying out extensive experiments upon the cross-breeding of grain, and here again considerable success has been attained.

Process of Cross-fertilisation.

In regard to the cross-breeding of grains it may be here mentioned that in all grains and flowers, as in animals, there is a male and female, and the process consists in fecundating the female of one variety with material called pollen taken

from the male of another. The process, although a little delicate, is not by any means difficult, and to carry it out does not require any special training in, or knowledge of botany.

Organs of Fructification.—The accompanying sketch, fig. 366 (for the use of which we are indebted to Messrs A. & C. Black), represents the organs of fructification, much enlarged, of a spikelet of wheat, the chaff-scales being removed for the sake of convenience. The round part, *o*, is the ovary, and what ultimately is the grain; the feathery parts, *s*, are the two styles, or female portions of the flower; while *e* represents the three stamens, or male portions of the flower. The tops of stamens are called anthers, while the tops of the styles are called stigmas. In all the grains the organs of fructification are very much alike, so that what is said regarding one, as a rule will apply to all. For the purpose of effecting cross-fertilisation of any variety, the anthers, *e*, are cut away before they are old enough to have deposited any pollen on the stigmas. If such has happened, cross-fertilisation cannot be effected, and all labour in that direction will be lost.

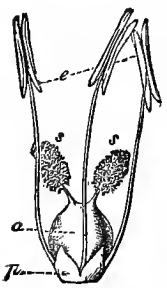


Fig. 366.—*Organs of fructification in wheat.*

Male and Female Influence.—Messrs James Carter & Co. have found in their trials that the length of straw is, in the bulk of cases, regulated by the male parent, while the length and form of ear appear to generally follow the female parent. In the animal kingdom, it is also found that in the majority of cases the male has the preponderating influence in forming the body, while the female generally imparts the greatest impression in regard to temper. In neither the one case nor the other, however, do these rules always hold good, as sometimes the produce bears no resemblance to either parent, so that although they may be true in a general way, it is the most that can be said of them.

Details of the Process.—As wheat is perhaps the easiest of all the grains to fructify artificially, a description of the process, as applied to it, shall be given. A variety having been selected, the stigmas of which it is desired to impregnate with the pollen-dust from the anthers of some other variety, the ear is taken as soon as it comes out of the sheath, and all the seed-vessels or spikelets are cut off except one, two, or three. This mutilation of the ear assists considerably the future operations, and if more than one seed-vessel is left on each ear, they should be left as far apart as possible. An ear is now procured of the variety which it is intended to use as a male parent, and which, if possible, should be about from three to five days out of the sheath, while the ear which has been prepared, and on which it is intended to operate, should not be over two days out of the sheath, otherwise risk of self-fertilisation will be run.

For convenience in carrying out successfully the delicate process of fertilisation, the operator should provide himself with a very small pair of forceps, so as to be able readily to pluck out the anthers from the one flower, and lift up those of the other. These may be made of a strip of thin steel, brass, or tin, about a couple of inches long, and quarter of an inch wide. Both ends of this strip are narrowed to about one-sixteenth of an inch broad at the points, the strip being then carefully bent over a lead pencil placed at the middle, while the two points are brought together and held in position by the finger and thumb. The ear, which it is intended to make the male parent, is then taken, and the spikelet gently opened by pressing the point of one of the fingers on the tips of the glumes, *B*, and palea, *A* (chaff), fig. 367. The chaff-scales having been thus opened, the anthers, *e*, will be exposed to view. The slender stems which support these are called filaments, which the operator now takes hold of with the forceps, and plucks out, laying each on a sheet of paper in order to be readily taken hold of again when required.

Enough anthers having been procured, the prepared ear, which it is intended to make the female parent, is taken, the chaff-scales *very carefully opened* as already described, and the anthers plucked out. If both ears have been

taken at the proper stage, the anthers of the one which it is intended to make the female parent will present a decided greenish tint, while the others will be more of a cream colour.

In plucking the anthers from the female parent, care should be taken to catch them by the *filaments only*, otherwise, if caught by the anthers (if too ripe), a portion of the pollen might be

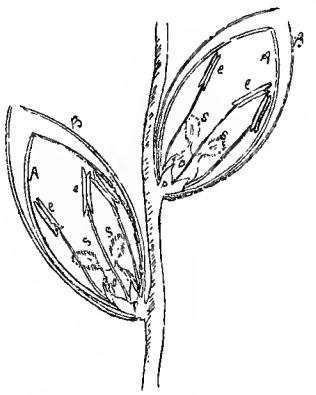


Fig. 367.—*Organs of fructification in wheat.*

shed on the stigmas, causing self-fertilisation. While the chaff-scales are being held open with the one hand, the anthers on the sheet of paper should be caught by the forceps, and dropped on the top of the stigmas, the chaff-scales or palea being then *very carefully closed*. In putting in the anthers, they are none the worse, but all the better, of being caught and pressed by the forceps, as if nearly ripe this forces out the pollen, there being no occasion to catch them by the filament, as when taken out. Care should, however, be taken not to bruise the feathery stigmas, otherwise fertilisation will not proceed. If the palea or chaff-scales are *not most accurately closed*, damp gets in and rots the feathery portion of the stigma, thus preventing fertilisation.

The pollen-dust retains its fertilising properties for several days, so that, although the female parent is not ripe enough for fecundation when the operation is performed, it becomes so very soon after, and long before the pollen-dust becomes useless.

The ear should now be securely tied to a stake and labelled with the names of both parents.

Time of Natural Fecundation.—It is a general belief among farmers that the grain is being fecundated when the anthers—or bloom, as it is called—appear on the outside of the ear. Such, however, is not the case, as fecundation has already been carried out, the expulsion of the anthers being an effort of nature to rid herself of what is now so much useless material, and the presence of which might interfere with the formation of the grain. The plant opens the chaff-scales and thrusts these out in good weather only, and as soon as they fall off by decay, or are broken off by the wind, the palea are again closed.

Good Weather Essential.—At this stage of the life of the plant, good weather appears to be necessary, not for the fertilisation of the plant, as has generally been supposed, but to prevent damp getting inside the palea at the time they are partially opened to get clear of the anthers. The smallest portion of damp getting on to the feathery stigmas causes them to rot; so that the farmer's idea, that good weather is necessary at this stage to ensure a full crop, is quite right, although its effect is slightly different from what it is popularly supposed to be.

Period for Crossing.—In order to prolong the period during which cross ing may be successfully carried on, a portion of the plants with which it is intended to operate should be cut over near to the ground before and after the stalks are formed, which has the effect of producing a late crop of ears. In this manner the period of crossing may at least be doubled.

First Year usually Unsatisfactory.—Seeds of grain which are produced by artificial crossing have a habit of always presenting themselves the first year in anything but a pleasing form. Whether or not this is brought about by injury to the stigmas or ovary during manipulation, or by the imperfect closing of the chaff-scales, it is difficult to say, so that inexperienced experimenters should not be discouraged when they are in the first year rewarded for their trouble with a badly formed or badly coloured grain, as the next season may quite change its

character. It is generally the second year, and it may be the third or fourth, before the true type of a grain can be said to be permanently fixed.

Percentage of Success.—In a favourable season, and in the hands of an experienced operator, from 25 to 75 per cent of the spikelets operated on may produce grains, while, if the operation is clumsily done, none may be produced.

Protecting the Ears.—As soon, however, as it is seen that the flowers have set, the ears should be encircled by fine wire gauze, or strong muslin, to prevent birds destroying the grain. The operation of crossing, for the sake of convenience, is generally performed near the side of a wheat plot; and the fixing of a stake to each plant is a necessity for identification, and this stake is almost sure to be made a resting-place by the sparrows and other small birds which infest the sides of wheat fields, so that if unprotected many grains are sure to be lost.

After Culture.—When the grains are ripened and thoroughly dried, they should at once be sown in 3- or 4-inch pots, one in each, in which they may be grown till late autumn or early spring, when they should be transferred to a piece of specially prepared land in the middle of an ordinary wheat field. Here they should be planted at least one foot asunder each way, with a space a foot or two clear from the ordinary crop. By giving the plants so much room, each tillers to its full extent, while the grain when ripe runs little risk of being stolen by birds.

Details of Messrs Carter's Experiments.—Mr H. Evershed gives the following details of Messrs Carter's experiments, in the *Journal of the Royal Agricultural Society of England*:[1]—

"In crossing red and white wheat together, a white sort called Fill-measure, with smooth chaff and square ears, was crossed with Selected Red Square Head wheat as the male parent. The offspring has longer straw than either parent, and longer ears than the male, which has, however, clearly influenced the cross-bred offspring in the shape of the ear and the colour of the grain. This same successful cross turns out to be satisfactory in regard to quality, as well as being one of the earliest wheats next to the Talavera group.

"Another cross between Royal Prize Red and another long-eared variety exhibits a curious freak, since the long, square, thick-set ears are distinct from those of either parent. In another cross between the same red wheat and a long-eared white wheat, as male, the influence of the latter has been most potent in the colour of the grain; while, curiously enough, the offspring ripens a fortnight earlier than either parent.

"A cross between a woolly-chaffed white wheat and a smooth-chaffed club-headed red for male, proves exceedingly productive and vigorous, one plant having yielded sixty ears, and a field crop having produced at the rate of fifty-four bushels per acre. The colour of the grain shows the influence of each parent alike.

"In another case square-headed white, female, and long-eared white, male, have produced a wheat which proves to be the last sort to thrust its ear from the sheath of the stem, while, next to Talavera, it is one of the earliest to mature. Except that the ear is closely packed, it favours most the male parent, having an ear and grain of the same colour and the same length of straw.

"A cross was effected between Talavera and Royal Prize Red for the purpose of obtaining the early habit and superb quality of the former, combined with the vigorous constitution of the latter. The result proves a decided success, the offspring of the cross, or rather the latest selection from it, possessing the desired qualities.

"The selection from a cross between a bearded April wheat and an American bearded variety proves earlier than either parent, with grain quite equal to that of the well-known Russian Kubanka. This, of course, is a spring wheat, and the habit derived from its parents must be kept up by constant sowing in spring.

"One of the most singular results of crossing is found in a sort which has received the characteristic name of Bird-proof. The female parent was Fill-measure, the male an American bearded wheat, and the cross exhibits sharp-pointed awns on some of the glumes at the apex of the ear — a defence which birds have shown themselves shy of approaching."

[1] Sec. Ser., vol. xxv. part 2, p. 260.

INSECT AND FUNGOID PESTS.

INSECT INJURY TO CROPS.

Amongst the many troubles which farmers have to contend against, few are so vexatious as the growing injury to their crops and stock from insect agency. The need of plain knowledge of how to meet the evil is therefore year by year more urgently demanding attention—the need increasing steadily as the increase in amount of cropped or stocked ground constantly affords a greater amount of food for the pests.

Services of Entomologists.—To the researches of John Curtis, afterwards to those of Professor Westwood, Life President of the Entomological Society, and still working in his honoured old age on this useful labour, we are indebted for a series of observations extending over many years, throwing light on the histories and means of prevention of insect pests of the farm, the orchard, and the garden. Then the valuable contributions made by our own agriculturists, of the successive attacks and means of lessening losses therefrom, which have been recorded each year now for twelve years in the annual reports of Miss Eleanor A. Ormerod, the Consulting Entomologist of the Royal Agricultural Society, form in themselves a most valuable library of reference, and especially as being in great part the precise record of agricultural work carried on by practical men.

Space does not allow us to enter here on detailed histories of insect attack. We refer merely to a few of the commonest kinds, and of the most troublesome of these we give figures, with a few observations serving as guides to the kind of treatment which has been found practically useful.

The epitome given in the following observations has been in part compiled by Mr F. W. Silvester, Recorder of Economic Entomology of the Herts Natural History Society, from various sources, but mainly by permission of Miss E. A. Ormerod (Consulting Entomologist of the Royal Agricultural Society of England), from the reports above mentioned, and other of her publications.

Miss Ormerod's personal study of these subjects and her publications are too well known to require comment, and we feel favoured in being permitted to avail ourselves of her serviceable work, and likewise of the illustrative figures, in several cases from her own pencil, which she kindly permits us to use.

The arrangement adopted by Miss Ormerod — that is, of alphabetical sequence—has been adhered to, and each of the attacked crops, and the pests which infest it, are dealt with separately.

BEANS.

Bean Aphis.

The black bean blight (*Aphis rumicis*), (fig. 368), is one of the very few insect attacks which can often be checked satisfactorily by direct treatment when the insects are settled on the plants.

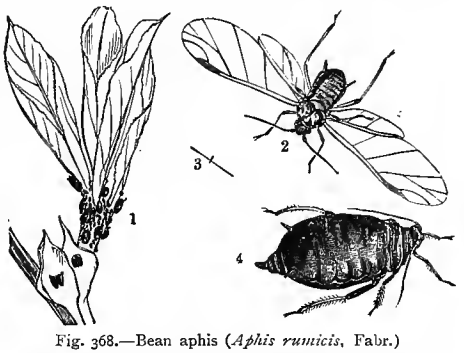


Fig. 368.—Bean aphis (*Aphis rumicis*, Fabr.)
1, Bean-shoot, with aphides; 2, Male, magnified; 3, Natural size; 4, Wingless female, magnified.

The attacks are begun by a few wingless females establishing themselves near the top of the bean-stalks at flowering time. These produce living young, and one generation succeeding another in rapid succession, the upper part of the plant soon becomes coated with the colliers, and a mere filthy mass of insects

and the sticky juices drawn from the plants.

Treatment.—The infested tops of the beans should be cut off as soon as "the colliers" appear. This treatment is very successful, if care is taken to carry off the infested tops and to destroy them. A healthy luxuriant growth in this, as in all cases of attack, is important. In garden cultivation, soot, or any dry dressing to make the bean-tops unpalatable to the aphides, is sometimes of service, especially if applied after rain, so as to adhere to the black lice and shoots.

Bean-seed Weevils.

These are chiefly injurious in this country by lessening the germinating power of the seed. Necessarily, as the plant in its first growth depends on the nutriment contained in the seed—where this nutriment is diminished in proportion to the amount of the future seed-leaves which are removed, the growing power is lessened, and a bad start made, which tells on the future plant-growth. This kind is certainly now naturalised, whether it was originally British or not. Curtis's name *granarius* is retained, as it is that under which he describes this species, but it appears that the species described is considered to be that which we know as *Bruchus rufimanus*.

Infested beans may be known by having a little round depression of the skin covering the end of the larval gallery; those that have been infested, by round holes where the beetle has escaped.

Prevention.—The great safeguard is to avoid sowing infested seed—a great deal of which is imported into this country—and in infected districts to change the crop frequently.

Where beans or peas are known to be infested, the beetles or chrysalids within may be destroyed by steeping. Water alone has been found in laboratory experiments to answer the purpose. For preparing seed for fields, the following dressing has been used: "Blue vitriol," 1 lb.; Macdougall's sewage carbolic, 1 pint; water, 6 quarts. The above dressed 6 bushels of beans, and the result was satisfactory in all ways.

The following simple and effective method of clearing beans or peas infested with weevils is recommended by Mr George Brown, Watten Mains, Caithness: "Procure an air-tight vessel—one of the tanks for holding water on board ship is an excellent article for the purpose. Put the beans or peas into this, filling up to within a foot of the top. Level the surface of the beans or peas, and set a lighted candle upon it. Close up the vessel so as to be quite air-tight. The burning candle uses up all the oxygen and develops carbonic acid, which is fatal to all animal life. This plan I have seen successfully adopted in South Africa for killing weevils in rice. When the tank is opened the entire surface is found to be covered, perhaps to a considerable depth, with dead weevils."

BEET AND MANGEL.

Beet Carrion Beetle.

Beet and mangel crops are sometimes attacked by the beet carrion beetle (*Silpha opaca*), which begins to prey upon the leaves as soon as they appear above ground, giving great trouble to the sugar-beet growers in France.

The grubs are much like the wood-lice in shape, black and about three-quarters of an inch long when full grown.

Prevention.—As the eggs are laid in putrid matter, it is advisable (to avoid repeated attacks) to put the manure on in autumn, and only use artificial at the time of sowing. Stronger manures, such as offal and sea-weed, or shore refuse, may bring it; and as it winters in decayed leaves, they should be removed. Mr Fisher Hobbs's turnip-fly preventive, consisting of lime, gas-lime, sulphur, and soot (the proportions of the mixture are given further on, under the head of Root Crops), has been found of service.

When the mangel is swept off in the seed-leaves, it is advisable to put in immediately another kind of crop. Turnips, carrots, parsnips, potatoes, peas, beans, and cabbage have been recorded as succeeding perfectly on land where the mangels had been destroyed.

Mangel-leaf Maggot.

Another well-known beet and mangel pest is the maggot of the *Anthomyia betæ*, Curtis (fig. 369). This damages the crops by feeding on the pulp of the leaves, which it often reduces to nothing

but dry skin. These white legless maggots are about the third of an inch long, of a yellowish white colour, and as soon as they are hatched, voraciously bore

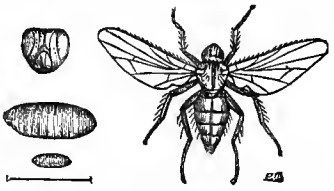


Fig. 369.—Beet-fly (*Anthomyia betæ*, Curtis).

Female, magnified; Line showing apread of wings, natural size; Head, magnified; Pupa, natural size and magnified.

through the skin of the leaf by the aid of two black hooks within the head-end.

Prevention. — Autumn cultivation, and measures to ensure a rapid growth, are the best means to combat with these maggots. Paraffin oil has been applied with success in the preparation of a mixture. Eight parts water, and one part soft-soap thoroughly incorporated, form the lye which takes mineral oil, and is said to amalgamate with whatever proportion of this may be added, the ingredients being mixed in a *boiling state* —of course applied cool.

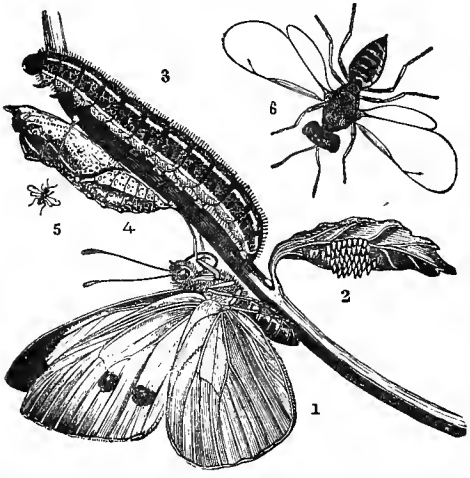


Fig. 370.—Large white cabbage butterfly (*Pieris brassicæ*, Latreille).

1, Female butterfly; 2, Eggs; 3, Caterpillar; 4, Chrysalis; 5 and 6, Parasite Chalcid-fly (*Pteromalus brassicæ*) natural size and magnified.

Hand-pulling of the plants has been found to answer in checking increase of attack in cases where the crop is still young and can bear thinning. The plants should be carried away and destroyed, and thus the maggots within will be got rid of before they can turn to chrysalids, and thence to flies, to start new attack.

Cabbages suffer very much from white

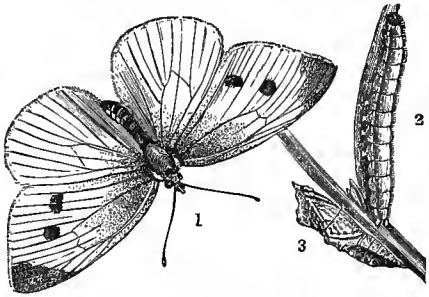


Fig. 371.—Small white cabbage butterfly (*Pieris rapæ*, Latreille)

1, Female butterfly; 2, Caterpillar; 3, Chrysalis.

butterfly caterpillar attack. We give illustrations of the two principal offenders,—the large white cabbage butterfly (*Pieris brassicæ*, Latreille), (fig. 370), and the small white cabbage butterfly (*Pieris rapæ*, Latreille), (fig. 371). Leaves on which the eggs are laid should be picked off, and the caterpillars searched for and destroyed. The caterpillars are more common in gardens, where they find congenial shelters, than in large open fields. Measures to promote a healthy growth should be adopted.

The ichneumon fly (*Microgaster glomeratus*) comes to our aid as a natural enemy to these caterpillars, in which it lays its eggs. The maggots from these eggs feed inside on all the parts not necessary to the caterpillar's life till the time comes for it to change to the chrysalis, when, instead of turning, it dies. The small yellowish cases collected in bunches much resembling silkworm cocoons, often seen on cabbages, are those of the ichneumon maggots. They should not be destroyed.

The great *measure of prevention* is searching for the chrysalids, which may be sometimes collected in handfuls from shelters under eaves, boards, &c., in the

neighbourhood of gardens; and sending boys on the ground to hand-pick the caterpillars, has been found useful as a remedy on the broad scale wanted in garden-farming.

CORN CROPS.

The following are some of the kinds of insects more especially prevalent in corn crops.

Corn Aphis.

With the corn aphis (*Aphis granaria*, Kirby), (fig. 372), we are almost unable to cope, as nothing can be done to get rid of it when on the corn ears: little is known of its winter habitat.

Daddy Longlegs.

Great damage is done to corn and turnip crops by the grub of the daddy longlegs (*Tipula oleracea*, Linn.), (fig. 373), which gnaws the young plant just below the surface of the ground, and thus stunts its growth. The crane-flies, as they are also called, deposit their eggs in neglected grassy spots—meadows and marshes.

The flies and grubs may be found throughout the summer; but when the latter change to the pupa state, especially from July to September, they can do no harm.

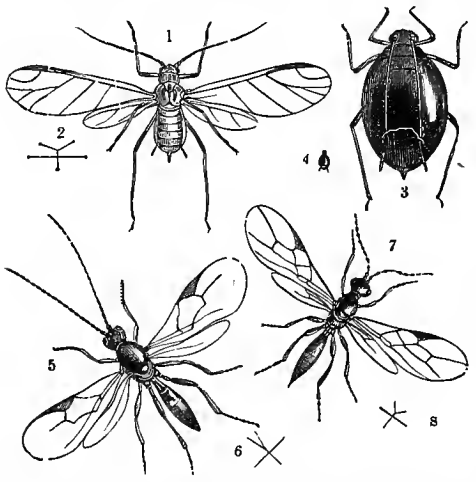


Fig. 372.—Grain aphis (*Aphis granaria*, Kirby).

1–4, Aphides, winged and wingless, natural size and magnified; 5 and 6, *Aphidius avenæ*; 7 and 8, *Ephedrus plagiator* (parasite flies), natural size and magnified.

Prevention.—In methods of prevention and remedy three great points should be considered—

1. Any measures tending to lessen the quantity of eggs laid.
2. Methods of cultivation which will destroy the egg or grub in infested ground, as deep ploughing, Croskill-rolling at night,[1] penning sheep, dressing with gas-lime, paring and burning—a practice now seldom pursued—and draining.
3. Manurial agents to encourage the healthy growth of the plant. Applications of soot are beneficial, as is also guano and a mixture of salt—4 cwt. to the acre; and *nitrate of soda* is particularly serviceable, as its use is beneficial to the plant and injurious to the grub. A spray of paraffin from the Strawsoniser (see p. 409) would probably kill the grub.

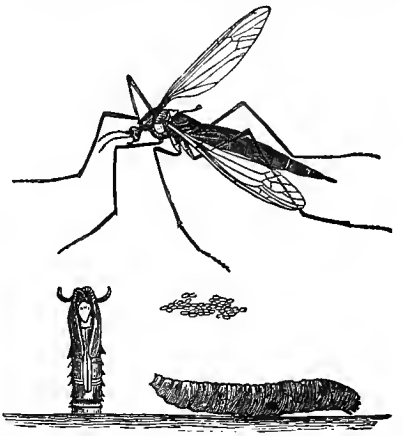


Fig. 373.—Daddy longlegs (*Tipula oleracea*, Linn.) Fly (after Taschenberg); Pupa and larva (after Curtis).

Corn-fly.

Another great enemy to our cornfields is the ribbon-footed corn-fly (*Chlorops tæniopus*, Curtis), (fig. 374). The injury is caused by the egg of the Chlorops being laid either on the lowest part of the ear itself or at its base, whilst the plant is young; and by feeding of the

[1] This is best at night or as early or late as can be managed, as the grubs are then more on the surface.

maggot hatched from it the growth is checked, and consequently the proper development of the ear is prevented. The distinctive mark of the Chlorops attack is the pitchy-brown furrow, from the base of the ear down to the first knot in the stem.

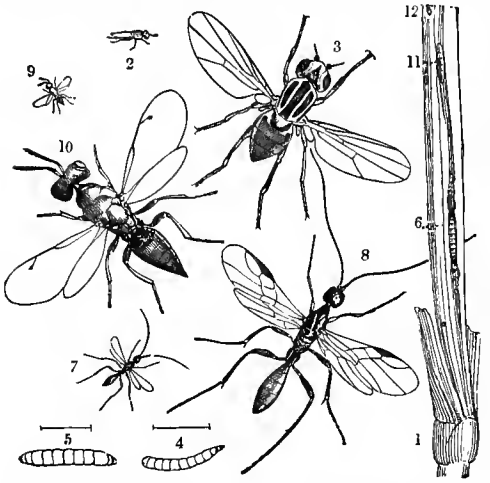


Fig. 374.—Ribbon-footed corn-fly; Gout (*Chlorops tæniopus*, Curtis).

2–6, Larva, pupa, and fly of *Chlorops tæniopus*, natural size and magnified parasite flies; 7 and 8, *Cœlinius niger;* 9 and 10, *Pteromalus micans*, natural size and magnified; 11, 11, and 12, Infested corn-stem.

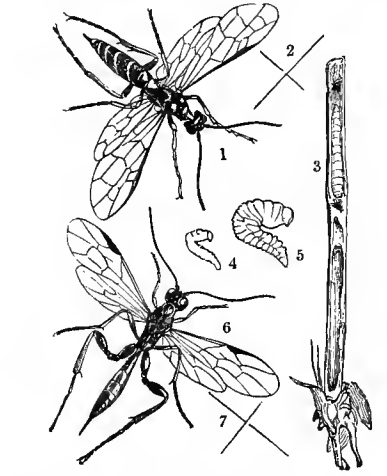


Fig. 375.—Corn saw-fly (*Cephus pygmæus*, Curtis).

1 and 2, Saw-fly, magnified and natural size; 3, Stem containing larva; 4 and 5, Larva, natural size and magnified; 6 and 7, Parasite fly (*Pachymerus calcitrator*) magnified and natural size.

Prevention.—Damp parts of the field appear to be liable to be infested. Drainage should be resorted to, and the application of any nitrogenous or ammoniacal manure combined with phosphates, to promote the healthy growth of the plant; as a great safeguard against attack is to keep the plant in good condition.

Corn Saw-fly.

The corn saw-fly (*Cephus pygmæus*, Curtis), (fig. 375), attacks by piercing a hole in the stem whilst it is young and soft, and laying an egg therein. Within this stem the maggot feeds, first making its way upward, and piercing the knots of the stem in its passage. Afterwards it descends, still within the stem, and about harvest-time gnaws a ring round the inner part of the stalk, just at the ground-level. Consequently on this injury the stem falls, and thus much damage is caused, both by loss on the ear and the twisted state of the straw.

Prevention.—The maggot winters in the stump; therefore any measures to destroy the infested stubble before the saw-fly comes out, in about the May of the following year, are the best means to prevent recurrence of attack.

Hessian Fly.

In 1886 a new pest was discovered in England. The Hessian fly (*Cecidomyia destructor*, Say), (fig. 376), was found to be present in some barley-fields near Hertford.

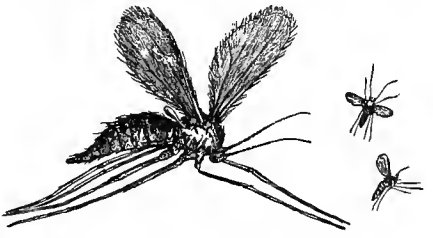


Fig. 376.—Hessian fly (*Cecidomyia destructor*, Say).

The following abstract, from a German source, gives its life-history: "The larvæ live in the haulm of wheat, rye, and barley.

The female flies usually lay their eggs on the young leaves twice in the year—in May and September—out of which eggs the maggots hatch in fourteen days. These work themselves in between the leaf-sheath and the stem, and fix themselves near the three lowest joints, often near the root, and suck the juices of the stem, so that later on, the ear, which only produces small or few grains, falls down at a sharp angle. Six or eight maggots may be found together, which turn to pupæ in spring or about the end of July, from which the flies develop in ten days." —(Stett. Ent. Zeit., xxi. p. 320.)

Miss Ormerod (from whose pamphlet on the subject this information is taken) found, on visiting the infested fields, the stems doubled sharply down a little above the joint, as shown in fig. 377, lower

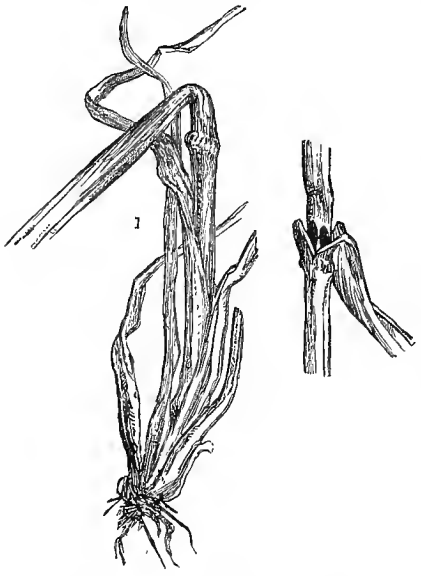


Fig. 377.—Hessian fly attack on barley.
1, Bent barley stem; 2, Leaf bent down, showing "flax-seeds."

down; and between this double and the joint there lay, closely pressed to the stem and covered by the sheathing-leaf, the flax-seed-like chrysalis-cases. The injury is caused by the fly-maggots, lying at the same spot, sucking the juices from the stem, which is thus weakened, and falls.

The Hessian fly has commonly two broods in the course of the year—the winter attack to the young plants, and the summer attack to the growing straw. The flies which come out in August or September from the "flax-seed" chrysalis-cases (sheltered above the second joint of the straw from the ground), lay their eggs, we are informed by various observers — Professor Riley, the State entomologist, amongst the number —in the grooves on the surface of the leaves, or between the stalk and sheath where loose, and, as soon as the footless larva or maggot hatches, it makes its way down the leaf to the base of the sheath, which in the young winter wheat is at the crown of the root.

This form of attack has not yet been reported in England. The summer attack with us is started chiefly from flax-seeds or chrysalids which have survived the winter. The flies from these "flax-seeds" come out in spring, or about the beginning of May, and as, where the corn is running up to stem the tender ground-leaves are no longer to be found, which are used for autumn egg-laying, the flies have no choice, but they lay them instead, as we know, so that the maggot,

Fig. 378.—Chlorops.
Stem attack showing maggot furrow.

when hatched, shelters itself between the stem and sheath, just above the first or second joint from the ground, and there it turns to the flax-seed chrysalis, from which the autumn brood presently come out.

How the pest came to this country we do not know, and very likely never shall. All evidence points to it having come from Russia and the east of Europe. In all probability it came either in foul corn, and was distributed in cheap screenings — or it may have come in straw; but the examinations of nearly a year of straw at receiving ports did not disclose more than one infested stalk.

Prevention. — Our chief method of prevention is in *late sowing, so that the young wheat will not be up until the autumn brood is dead* —this is a most important precaution. All measures to secure hearty good growth are very desirable; so is rotation of crop, and it should be borne in mind that strong-stemmed corn is less liable to attack than the kinds of which the outside is more readily injured by the maggot

One most important measure to prevent recurrence of attack from infestation present in any locality is *destruction of siftings*, in which the flax-seeds, as they are called, are thrown by the threshing-machines. These chrysalids are often present in great numbers, and would if left be the origin of next year's attack; and if burnt together with the rubbish in which they lie great danger will be spared. Miss Ormerod, in the preface of her second report on this subject, thinks "the experience of last season has removed much cause for anxiety" on the score of the Hessian fly; and the attack of 1888—so far as reported—was enormously less in amount than that of 1887.

It may be of use to mention the differences between the three great corn pests. Hessian fly attack is at once known by the stem falling at an acute angle, usually about the second joint (fig. 377). The special mark of *Chlorops* attack is the pitchy-brown furrow, from the base of the ear down to the first knot of the stem; whilst the corn saw-fly (*Cephus pygmæus*) cuts the corn off near the ground (fig. 378).

Wheat-midge.

The "red maggot" or larva of the *Cecidomyia tritici*, Kirby, (fig. 379), so troublesome in Canada, often does harm by injuring young grains of wheat in the ear. The *C. tritici*, or wheat-midge, is like a very small gnat, of the shape figured above, and of a yellow colour.

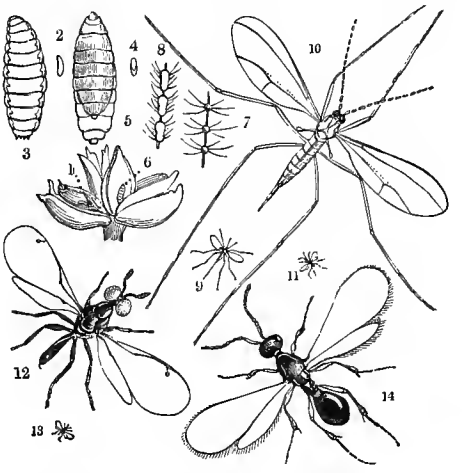


Fig. 379.—Wheat-midge (*Cecidomyia tritici*, Kirby).

1, Infested floret; 2-6, Larva and cased-larva (? pupa), natural size and magnified; 7 and 8, Joints of antennæ, magnified; 9 and 10, *C. tritici*, natural size and magnified. Parasite flies: 11 and 14, *Platygaster tipulæ*; 12 and 13, *Macroglenes penetrans*, natural size and magnified.

When the wheat blooms in June, the midges may be seen laying their eggs, especially during the evening. The maggots, which are orange colour and legless, but wrinkled transversely into folds, by means of which they wriggle themselves along, are in large numbers stored with the corn when cut, while others, which leave the ear, go down into the ground.

Prevention. — To destroy the maggot in screenings, or to resort to such methods of cultivation as will destroy it when in the ground. Deep ploughing with a skim coulter, which will take off a thin slip, and bury this down under a succeeding land slice. Chaff and rubbish from the threshing-machines should be burnt; firing the stubbles is good; also destroying such wild grasses as the midge

is known to frequent, notably the wild oat, *Avena fatua.*

Wire-worm.

We now come to a most important injurious insect, whose ravages are very widespread, the wire-worm or grub of

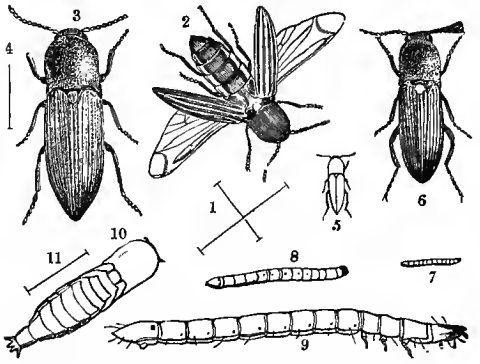


Fig. 380.—Wire-worms; Grubs of Click beetles (*Elater lineatus, Elater obscurus*, and *Elater sputator*, Linn.; and *Elater ruficaudis*, Gyll.)

1 and 2, *E. lineatus;* 3 and 4, *E. obscurus;* 5 and 6, *E. sputator*, natural size and magnified; 7, Larva of *E. sputator(?);* 8 and 9, Larva of *E. lineatus*, natural size and magnified; 10 and 11, Pupa of wire-worm magnified—the straight lines show natural length.

various kinds of click beetles. (See fig. 380.)

These may easily be known by their hard shiny yellow appearance, like a short bit of flattened wire. They should be distinguished from the grubs of other insects, and insect allies which pass

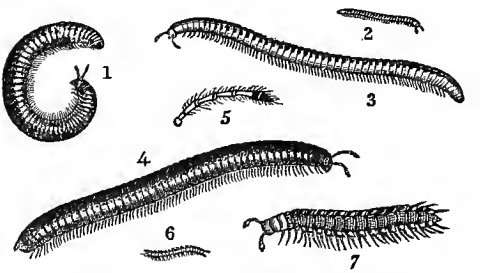


Fig. 381.—False wire-worms.

Snake millepedes: 1, *Julus Londinensis;* 2 and 3, *J. guttatus*, natural size and magnified; 4, *J. terrestris;* 5, Horn; 6 and 7, Flattened millepede, *Polydesmus complanatu*, natural size and magnified.

under the name of false wire-worms, millepedes, or Julus worms, shown in illustration (fig. 381). From their method of gnawing roots or underground shoots, and then going to another plant, they waste and destroy more than they require for food.

The egg from which this grub is hatched is laid either in the earth close to the root of a plant, or between the sheathing leaves near the base of the stem. On being hatched, the grub or wire-worm eats into the stem just above the true root, and sometimes eats its way up to the middle of the stalk. Wire-worms are said to live five years in the grub state: they go down deeper in the ground as the frost increases; they feed voraciously near the surface till the time has come to turn to the chrysalis (or pupa); they then go deep into the soil, and form an earth-cell in which they change, and from which the perfect beetle comes up through the earth in two or three weeks, generally about the first weeks in August, or they may pass the winter in this state, and the beetles develop the next spring.

Prevention.—As clover leys and broken-up pasture-land often swarm with these grubs, paring and burning is advantageous, care being taken to burn the rubbish as soon as possible, or the wire-worm will soon secure itself below. Soot and guano has stopped the mischief on a bad crop of oats. Nitrate of soda and salt are beneficial, also soda ash. Rape-dust is a good stimulating manure, and rape-cake, as has been proved, acts beneficially by enticing the wire-worms from the crop.

Moles, rooks, plovers, and pee-wits assist us greatly in keeping down wire-worms, and it should be borne in mind white mustard has been found to act well as a clearing crop on infested land.

Ear Cockles.

"False ergot," "purples," or "ear cockles" attack of ears of wheat (a small purple gall-like growth), is caused by the eel-worms (*Tylenchus tritici*), (fig. 382), of the family *Anguillulidæ.* The colour is yellowish white, and the largest wormlets are from a seventh to even a quarter of an inch in length.

Prevention.—As a method of preven-

tion, "pickling" with sulphate of copper, or dilute sulphuric acid, is supposed to be of service in killing the wormlets in the cockle-galls.

Another species of eelworm—the *Tylenchus devastatrix* of Kuhn, is the cause

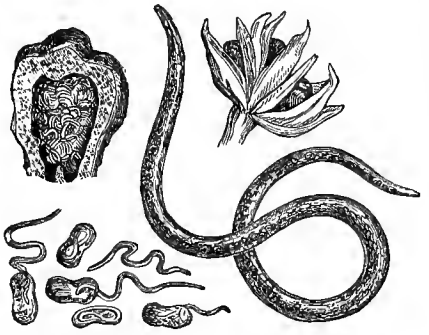


Fig. 382.—Ear cockles (*Tylenchus tritici*). Wheat cockle-gall; Eelworm.

of very serious injury to different crops, and especially to oat plants and clover. In oats the small microscopic eelworms which infest the inside of the plant give rise to the deformed bulb-like growth at the base of the stem known as "tulip-root" (fig. 383). In clover, one of the most common forms of disease, or "sickness," as it is called, is also owing to the presence of the *T. devastatrix* in the shoots, which are often shortened and thickened in growth; and in bad cases have the side shoots stunted into mere rounded bunches of leaves aborted into scales, set thickly along the stems.

Fig. 383.—Tulip-rooted oat plant infested by eelworm.

The use of a mixture of phosphate of potash and phosphate of ammonia, at the rate of about 4 cwt. the acre, has been found to answer extremely well as an application where eelworm is present, and deep ploughing (with a skim coulter), so as to bury down the surface of the land where infested crops have grown, is a very serviceable method of prevention.

The attack of this destructive species of nematode or thread-worm has for some years been specially studied for practical use (as well as scientifically in connection with two of the chief Continental experts) by Miss Ormerod, and details of the progressive observations will be found in her yearly reports. A complete account of the attack in connection with clover, with notes of serviceable means of remedy, and also good figures of the wormlet, appear in her Thirteenth (1889) Annual Report.

Before quiting corn pests we must just allude to the corn thrips (*Thrips cerealium*, Haliday) which infest damp spots and late-sown corn. Draining and good cultivation are the only practicable remedies.

HOPS.

Hop-fly.

Hop plants, both above and below ground, are liable to attacks from several kinds of insects, and the losses to planters occasioned by the hop-fly have been almost incalculable. It appears they have been of more frequent occurrence during the past fifty years.

The hop aphis is of the genus *Phorodon*, so named from the toothed or gibbous form of the first joint of the antennæ, and from the toothed frontal tubercles, which are most developed in the wingless viviparous females. For the mode of attack, and for the remedies and further details, the reader is referred to the Report of Mr C. Whitehead, our highest authority on hop-growing.[1] The following notes, taken almost entirely from Mr Whitehead's writing, contain observations of some of the chief hop pests, and common methods of treatment.

Hop Aphis (Aphis humuli), (fig. 384).

The hop-aphis appears upon the hop plants generally about the beginning of May, and if the conditions of temperature and of the plants are favourable, it propagates with astonishing rapidity. The never-ending still-beginning swarms live entirely upon the sap of the plants, and suck it up by a kind of pumping process

[1] Report on Insects Injurious to Hop Plants, by Charles Whitehead, Esq., F.L.S., F.G.S., prepared for the Agricultural Department. Eyre & Spottiswoode.

with their monstrously long beaks, attacking first the youngest and smallest leaves of the leading shoots, which are more succulent than the older leaves. After a week or two the growth of the plants is checked, and they struggle in vain to reach the tops of the poles. Their juices

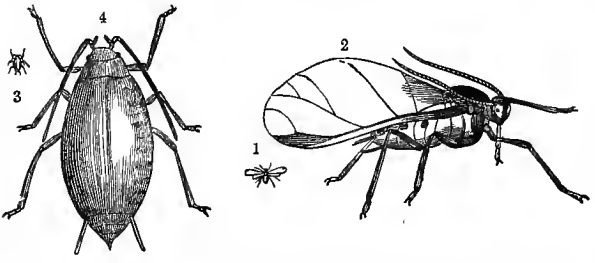


Fig. 384.—Hop aphis; Green fly (*Phorodon humuli*, Schrank).
1 and 2, Female aphis, natural size and magnified; 3 and 4, Larvæ or "nits," natural size and magnified.

are exhausted by the continuous suckings of these insects, and the respiratory action of the leaves is stopped as to their under surfaces, upon which the aphides always congregate and feed, by their filth and exuviæ, and upon their upper surfaces by the "honey dew," a peculiar glutinous sweet secretion ejected from the bodies of the aphides; this falling upon the leaves effectually prevents them from absorbing oxygen into their tissues. After this, which, as a rule, happens from three weeks to a month after the appearance of the insects, the plants give up, the leaves turn black and fall off, and all chances of a crop are lost.

Prevention. — Professor Riley's observations during the past season have proved the migration of *Phorodon humuli*, Schrank, between plum and hop—an important fact, previously much believed in, but not absolutely demonstrated. Therefore, when damson-trees are infested in the neighbourhood of hop-grounds, they should be washed with soft soap, &c., to prevent this migration.

The best *remedial measure* is to use the well-known hop-wash, the composition of which is—

100 gallons of water, soft water if possible, or, if hard, with soda added.
4 to 5 lb. of soft soap.
6 to 8 lb. of quassia, boiled well to get full extract.

This is applied by means of large garden-engines, with strong pumps, the jets being held under the leaves by men. In the case of large plantations, horse washing-machines are used. To ensure success the wash must be applied as soon as the lice are seen on the leaves, and must be continued till all these have been cleared off.

The *Coccinellæ* (lady-birds) are the hop-fly's great natural enemies, and they have often been known to appear in such large numbers as to avert an impending blight.

Minor measures consist in carefully removing what may be shelters of infestation, as pieces of dead bine, &c., before February, and the application during the winter of lime, soot, and caustic substances round the stocks.

Wire-worm in Hops.

Wire-worms, the larvæ of the striped click-beetle, *Agrotis lineatus*, are the first enemy to attack the hop. They often do much mischief by gnawing the sets directly they are planted, and eating off the radicles and shoots as soon as they are formed. This plague is most prevalent upon land that has been broken up from old pasture. Several acres are sometimes so much destroyed as to require replanting. The plan recommended by Mr Charles Whitehead for getting rid of wire-worms in a hop-ground, is to put pieces of mangel, carrot, or turnip or rape-cake close round the "hills," and to examine these once or twice a-week, and capture the wire-worms that have burrowed into them.

Slugs.

Little black slugs, if undisturbed, attack and devour the shoots or bines as they appear. This plague may be pretty effectually prevented by sprinkling quicklime over the "hills" very early in the morning.

Cone-fly.

The hop cone-fly or fever-fly (*Dilophus vulgaris*), which revels in manure-heaps, is often troublesome, and so is the hop-

jumper (*Euacanthus interruptus*, Linn.), fig. 385, for which the only *remedy* proved to be practical and effectual, is to hold tarred boards or sacking on two sides of the plant, low down in the

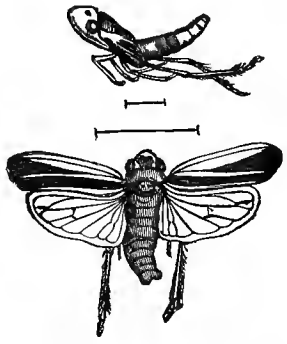


Fig. 385.—Hop-jumper (*Euacanthus interruptus*, Linn.)

alleys, and to have the poles smartly tapped with a stout stick. Washings do not appear to have any effect on the jumpers.

Hop-flea.

The hop-flea (*Haltica concinna*, Curtis), like its congener the turnip-flea, rejoices in cloddy ground, so it is desirable to well work round the plant-centres early, and get a good season all over the plantation as soon as possible after poling.

One means of *preventing* the spread of these beetles is to have the pieces of the old bines moved away after hop-picking. After a bad attack, lime, soot, &c., should be applied in October.

The caterpillar of the ghost moth (*Hepialus humuli*, Stephens), and the hop-bug (*Lygus umbellatarum*), which lives by suction, are two other hop pests, but not so important as the hop aphis and the red spider (*Tetranychus telarius*, Linn.), fig. 386.

Red Spider.

The red spider, which is so troublesome in hot and dry seasons, is neither an insect nor a spider, but, strictly speaking, a "spinning mite"—that is, belongs to the genus *Tetranychus*, of the order *Acarina* or mites. Mr Andrew Murray thus describes its work: "On leaves (especially the under side of them) it finds a fit hold, and spins its web, affixing the threads to the prominences and hairs of the leaf; and under this shelter a colony, consisting of many of both sexes in maturity, and young in all their ages, feed and multiply with rapidity. The plant soon shows the influence of their presence in its sickly yellow hue; the sap is sucked by myriad insect-mouths from the vessels of the leaf, and its pores are choked by excremental fluids."

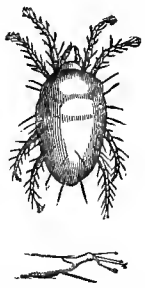


Fig. 386.—Red spider (*Tetranychus telarius*, Linn.)

Prevention.—The hop-wash, previously described, is the only effectual remedy. Poles should be well shaved before they are set up, as their bark harbours these mites, and many other insects injurious to hop plants.

Thousand Legs.

On undrained lands the thousand legs (*Julus Londinensis*, *J. guttatus*, *&c.*) are often troublesome.

Prevention.—Thorough cultivation of the land, especially turning the surface early in the year, and removing all vegetable and decaying matter which would serve as a shelter for them. Where nitrate of soda or salt can be applied so as to reach them in solution, this is an immediate destruction to the spotted millepede the *Julus guttatus*, and salt, lime, nitrate of soda, and other alkaline applications are found serviceable as deterrents.

Hops are also liable to attack from the hop frog-fly (*Eupteryx picta*, Fab.), the hop dog-caterpillar of pale tussack moth (*Dasychira pudibunda*, Linn.), and the caterpillar of the hop-vine snout moth (*Pyralis rostralis*, Linn.), the injuries of which may be lessened respectively by use of tarred boards or syringing.

ONIONS.

Onions—an important crop in the south of England—are often attacked with most disastrous results by the onion-fly (*Anthomyia ceparum*, Bouche), fig. 387. The injury is caused by the

maggots feeding inside the onion bulbs, which are often completely destroyed. These maggots may be found as early as May. When hatched the maggots make their way into the lowest part of the bulb, where they feed for a fortnight, and then go down into the earth, and turn into the chestnut-coloured "fly-

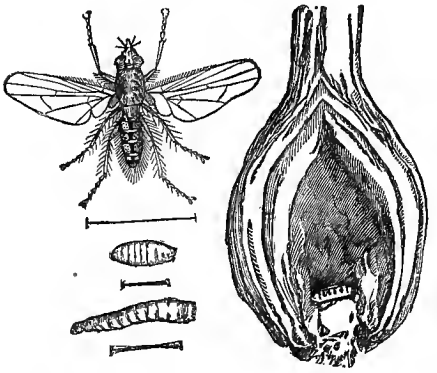


Fig. 387.—Onion-fly (*Anthomyia ceparum*, Bouche).

cases." From these the fly comes out in ten to twenty days in summer, and proceeds to egg-laying, and so the destruction goes on as long as the onions remain and the warm weather lasts.

Prevention.—Miss Ormerod has noticed that the onion-maggot can creep from an infested bulb to those near, and to avoid this spreading it is important to carefully remove each injured bulb, with the earth round it. Or the bulb may be destroyed by letting a few drops of carbolic acid fall on it, which will spread through the decayed tissues, and kill the grubs, but will do no harm, as nothing live is growing on the spot.

Amongst the remedies that have been tried are sprinkling sand saturated with paraffin amongst the onions, also putting on a dressing of soot on a damp morning. And in garden cultivation, watering with soap-suds and house-slops is a good old-fashioned remedy.

A most effectual method of *preventing* attack occurring, is to grow the onions in trenches, and keep the bulbs so far covered with earth that the fly cannot reach them to oviposit. This has been tried with success both in England and Canada.

Where onion-beds have been much infested, it is a good plan to trench down the surface-soil in autumn, and so bury the maggots or chrysalids that may remain on the ground too deeply to cause further mischief.

PEAS.

Peas are often attacked by the caterpillars of the pea moth (*Grapholitha pisana*, Curtis). These cause the "maggoty peas" often found in old pods when the crop is maturing.

Prevention.—In gardens where the peas are picked green, a large number of maggots are destroyed with them; but in field cultivation, where the attack is noticeable, the haulm should be cleared away and burnt, or it may be burnt along the rows where it has stood, to destroy the caterpillar in the ground. It has been found to answer the purpose if it is buried beneath wet manure. Alteration of cropping, so that peas are not taken too often on infested ground, is a desirable means of prevention.

Pea and Bean Weevils.

The greatest enemies to leguminous crops are the pea and bean weevils (*Sitona lineata*, Linn.; *Sitona crinita*,

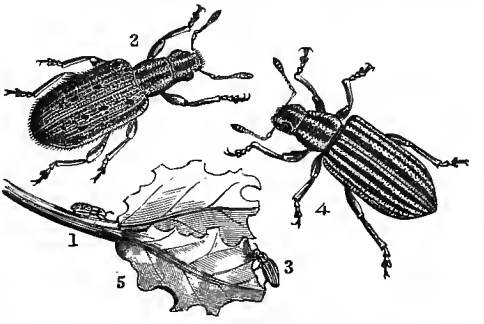


Fig. 388.—Pea and bean weevils (*Sitona lineata*, Linn.; *Sitona crinita*, Olivier).

1 and 2, *S. crinita*, natural size and magnified; 3 and 4, *S. lineata*, natural size and magnified; 5, Leaf notched by weevils.

Olivier), fig. 388. The attack is known by the leaves being scooped out at the edge. The beetles begin their ravages at the outsides of the leaves, and often eat all except the central rib. The striped

pea weevil *Sitona lineata* is of an ochreous or light clay colour, the horns and legs are reddish. The spotted pea weevil (*Sitona crinita*) is rather smaller and more of a grey colour; the wing-cases have short bristly hairs down the furrows, and are spotted with black.

The maggots have been found, by the observations taken in the last few years, to feed at the roots of peas and clover, and may be found in large numbers at clover roots during the winter. The weevils until lately were supposed to feed by day, and shelter themselves in the ground under clots or rubbish at night, but more recently they have been observed to be night-feeders also.

Prevention.—As pea crops suffer most from weevil attacks in the early stages of their growth, it is most important the soil should be well pulverised, and an available supply of manure beneath to push on the growth of the plant. Dressings of lime and soot (applied when the peas are wet) are good. Starlings and insectivorous birds are very fond of these weevils; but it has been observed that though these birds visited an infested field in large numbers, not one house-sparrow was seen till the peas were large enough to peck out of the pod.

Care should be taken to have the weevils swept out from the bottom of waggons and carts when the crop is being carted home, and also to remove them from platforms of the threshers, and burn them.

POTATOES.

The potato, which has become such an important factor in the rotation of most farmers, was, in the year 1877, threatened with the Colorado beetle (*Doryphoru decemlineata*, Say), fig. 389; but as it has not yet obtained a footing, and as our climate is too cold for it, we are likely to escape the attack. In case it should appear, the subject is before the public in the Government circular.

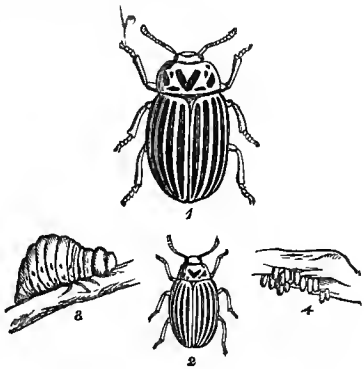


Fig. 389.—Colorado beetle (*Doryphoru decemlineata*, Say).

The eggs, figured above, are laid on the young shoots or beneath the leaves of the potato; the grubs are orange or reddish, and change to pupæ in the ground; and the beetles are also distinguishable by their orange colour and by having (besides a large black spear-shaped mark on the back) *ten* black stripes on the wing-cases—five stripes upon each.

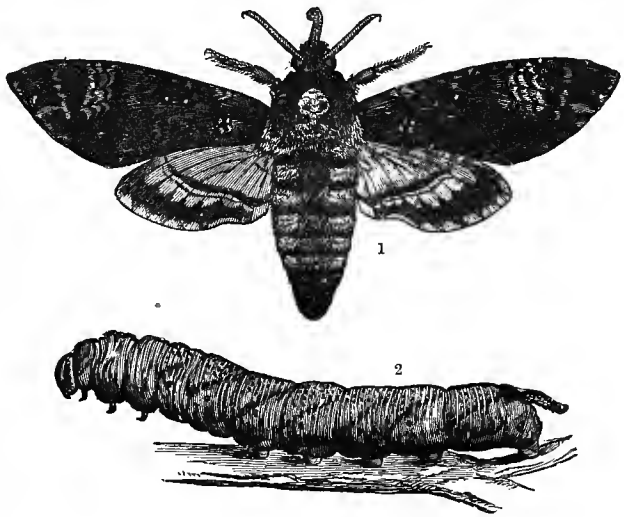


Fig. 390.—Death's-head moth (*Sphinx atropos*).
1, Moth; 2. Caterpillar.

The caterpillar of the death's-head moth (*Sphinx atropos*), fig. 390, is sometimes found in large numbers feeding on potato-leaves. It usually feeds by night; and when it is noticed as doing great damage, it is advisable to resort to hand-picking in the twilight, or by moonlight,—the great size of the grubs renders them easily distinguishable.

TURNIPS.

The annual loss incurred by insect pests injurious to turnips and other root crops is of serious proportions, while many of the remedies found to be of practical service are within the reach of every farmer. A great deal of useful information relating to the turnip-fly will be found in Miss Ormerod's Report on the widespread ravages of this troublesome pest in 1881.

The Turnip-fly.

The fly, or, more properly, the flea, beetles (*Phyllotreta nemorum*, Chevrolat), fig. 391, live through the winter—in a torpid state, or otherwise, according to the amount of cold—and under such shelter as is afforded only too often by rough ground, stones, or apparently almost any kind of moderately dry field rubbish.

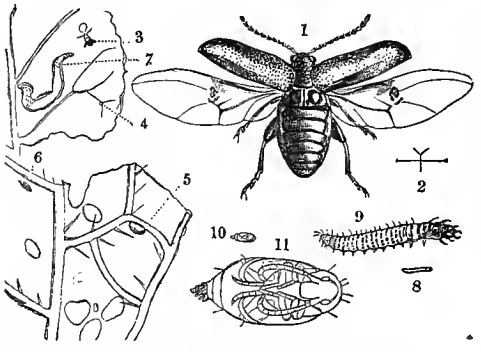


Fig. 391.—Turnip-fly (*Phyllotreta nemorum*, Chevrolat). 1–3, *H. nemorum*; 4 and 5, Eggs; 6–9, Maggot; 10 and 11 Pupa; all natural size and magnified.

With the return of sunshine they come out to trouble us, and feed, until the turnips and cabbage are ready for them, on shepherd's-purse, Jack-by-the-hedge, ladies' smock, charlock, and other wild Cruciferæ.

Prevention.—As the fly will appear before turnips are sown, it is most important to clear away charlocks and other weeds suitable for its food.

One spring, a field in good tilth, ready for turnips, suddenly became a mass of charlocks. This was entirely cleared away by the fly, which again appeared and preyed on the turnips when sown. Had the precaution of harrowing up the charlock as soon as it appeared been taken, the turnips would in all probability have been saved.

In coping with the turnip-fly the following *especial points* should be observed: 1st, cleaning the ground; 2d, destroying rubbish round the fields, or any rough nooks which might serve as winter shelters to the flea-beetles; 3d, so preparing the ground by good cultivation and plenty of manure that the growth of the turnips may be pushed on vigorously past the first leaves, in which they are most subject to the fly: where it is possible, autumn cultivation is desirable, so that at turnip-sowing the upper surface will only require slight disturbance, and thus the moisture beneath, which is a great desideratum for the young turnips, will remain to aid the growth; 4th, all dustings, dressings, &c., should take place when the dew is on the leaf, and the fly exposed to them, *not* in bright sunshine, when the fly would escape. If a rapid healthy growth can be ensured, the young plants are less likely to succumb. The old adage—

> "Where clods prevail
> The turnips fail"—

speaks volumes. The importance of keeping the moisture in the ground at sowing-time, and the advisability of autumn cultivation, thick seeding, rolling in the early morning when the dew is on the plants, are points to be attended to.

Mr Fisher Hobbs's celebrated remedy for the fly is as follows:—

"1 bushel of white gas-ashes" (gas-lime) "fresh from the gas-house, 1 bushel of fresh lime from the kiln, 6 lb. of sulphur, and 10 lb. of soot, well mixed together and got to as fine a powder as possible, so that it may adhere to the

young plant. The above is sufficient for two acres, when drilled at 27 inches. It should be applied very early in the morning *when the dew is on the leaf*, a broadcast machine being the most expeditious mode of distributing it; or it may be sprinkled with the hand carefully over the rows."

In all probability it will be found that "Strawsonising" (see below) the infested crop with some liquid or dry mixture which will kill the insects, will be the most practical remedy of the future.

THE STRAWSONISER.

This machine has been employed with such marked success in preventing the ravages of the turnip-fly and other crop pests, that particular notice of it should be made here. It was invented by Mr G. F. Strawson, Newbury, Berks, and is likely to prove one of the most important inventions of the time to farmers and growers of bushes and trees. This machine was first exhibited at the show of the Royal Counties Agricultural Society at Bournemouth in 1888, and its remarkable accomplishments have become speedily known.

It is really an air-power distributor, and it introduces for the first time the pneumatic power in the cultivation of field crops.

In its agricultural form (as shown in fig. 392) it is a light machine on a pair of wheels, and drawn by one horse. The

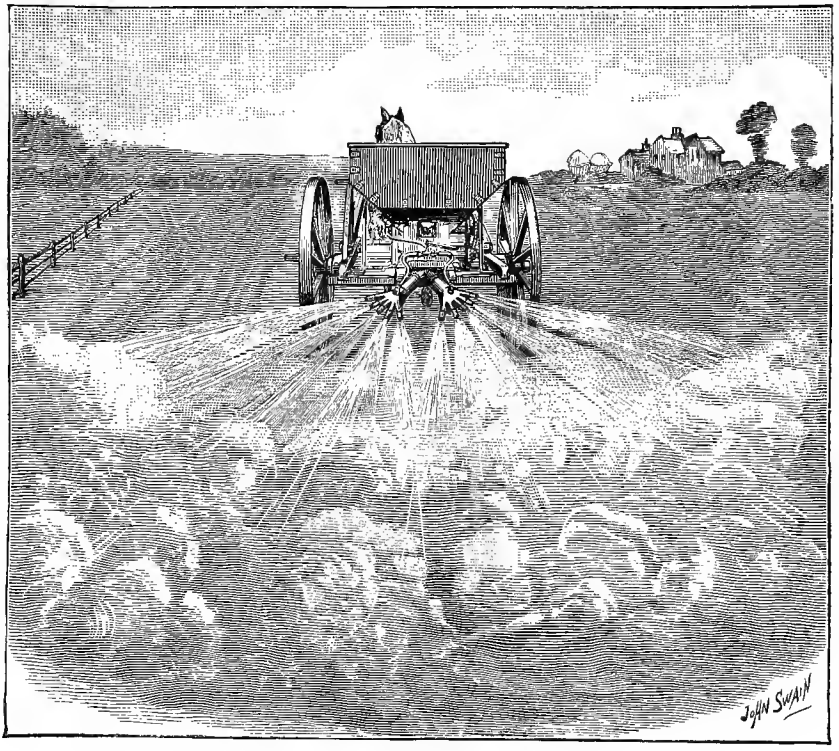


Fig. 392.—*The Strawsoniser at work.*

revolution of the road-wheels gives, by suitable gearing, a strong blast of air from a powerful blower; over this blast of air is placed the hopper containing the material to be spread, either dry or liquid, which is gradually fed into the current. The quantity to be fed is, in the case of liquids, regulated by cocks.

There is therefore, practically, no limit to the accuracy of adjustment; like water it may be turned on from the tiniest jet to a full stream. In the case of solids, a sliding shutter regulates the quantity, which can be instantly started or stopped by levers in command of the driver. The machines are constructed chiefly of iron and suitable metal to give requisite strength and durability. The regulation and management of the machines are very simple.

By the use of this ingenious machine the thinnest and most attenuated films can be spread evenly over land or growing crops.

The almost omnipresence of minute insect or fungoid devastators demands that the distribution should be nearly perfect in order to reach their microscopic bodies. In many trials the ravages of the turnip-"fly" or flea-beetle have been completely checked by distributing 1 gallon of paraffin to the acre with this machine. Freshly slacked lime, and also lime and sulphur finely prepared, have also been effectual when put on in the same way.

The pneumatic power is so perfect an agent that it can deal effectively with fine particles that are invisible to the naked eye, or those larger and heavier substances, such as the grains of nitrate of soda, clover seeds, and wheat maize, &c. Nitrate of soda, for instance, may be spread over the land most perfectly in quantities from 28 lb. to 4 or 5 cwt. per acre, while it will also sow farm seeds at the rate of from 10 lb. to 4 bushels per acre.

Besides being useful for these ground crops the machine may be made to distribute vertically or horizontally as occasion may require, to suit the applications to various plants, such as hops, vines, shrubs, and trees. Its use is also suggested for spreading salt on snow, and sand on slippery roads, as well as disinfectants over cattle runs, market, streets, and other places.

The Green Fly, &c.

The green fly, or turnip aphis (*Aphis rapæ*, Curtis), fig. 393, common to so many plants, is especially hurtful to turnips, swedes, and many other crops. It is chiefly found on the under sides of the leaves, and is most troublesome in dry seasons. Titmice, ladybird beetles and their grubs, are its natural enemies.

Prevention.—Washings—*i.e.*, drenchings with soap-suds, or even with pure

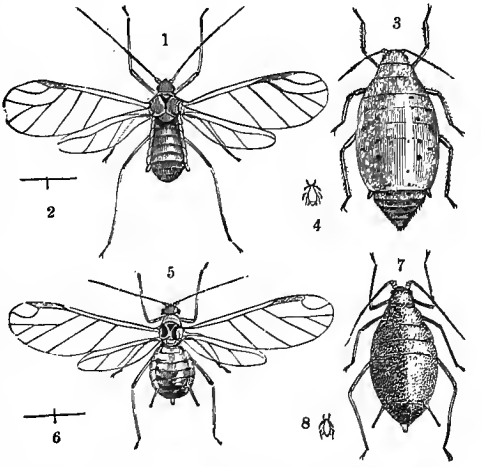


Fig. 393.—Turnip aphis; Turnip green fly (*Aphis rapæ*, Curtis; *Aphis floris-rapæ*, Curtis).

1–4, *Aphis floris-rapæ*; 5–8, *Aphis rapæ*, natural size and magnified.

water—and also waterings, especially with manure-water, are serviceable in garden cultivation, but up to the present time have been rarely attempted for field use. Now, in all probability, the fluid or dry dressings given by the "Strawsoniser" mentioned above will be of great use.

The turnip-leaf is also attacked by maggots of two kinds of *Diptera—Phytomyza nigricornis*, Macquard, the black leaf miner; and *Drosophila plana*, Fallen, the yellow leaf miner. These, and caterpillar of the diamond-back turnip moth (*Cerostoma xylostella*, Curtis), though seldom observed, sometimes clear all before them.

Dart Moth Maggot.

The caterpillar of the common dart moth (*Agrotis segetum*, Westwood), fig. 394, is often very destructive. Whilst the plants are young they gnaw off the tops, or drag the leaves down to their burrows to be eaten during the day. When the bulbs are formed, they estab-

lish themselves inside and feed on them. Sometimes 12 or 14 have been found in one root.

Prevention. — *Catch cropping* is a good remedy for the destruction of these caterpillars, and, where possible, turning

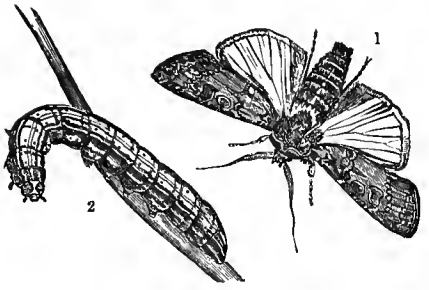


Fig. 394.—Dart moth (*Agrotis segetum*, Westwood). 1, Moth; 2, Caterpillar.

up the earth round plants and hand-picking. The encouragement of birds that especially feed on them, such as the crow, the rook, and the partridge, is worthy of attention.

Bird assistance in destroying injurious insects is not sufficiently appreciated.

The caterpillar of the heart and dart moth (*Noctua exclamationis*, Linn.), and all other surface caterpillars, should be dealt with in the same way.

Turnip Saw-fly Grub.

The mischief caused by the grubs of the turnip saw-fly (*Athalia spinarum*, Fabricius), fig. 395, is very great, in

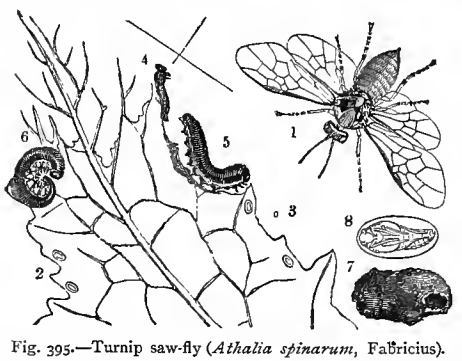


Fig. 395.—Turnip saw-fly (*Athalia spinarum*, Fabricius). Caterpillars, pupa, and pupa-case; Saw-fly, magnified, with lines showing natural size.

consequence of their voracious appetites (they begin to feed as soon as hatched) and the rapid succession of broods. They are known as "blacks," "black palmers," "niggers," &c. They will sometimes clear off the leafage of a whole field. The following diagram (fig. 396) will give an idea of their destructiveness.

One saw-fly will lay from 200 to 300 eggs, and these will hatch in five days, or less in warm weather. When full grown, in about three weeks they go down to the earth and spin a silken cocoon; from these cocoons the saw-flies emerge in about three weeks. It should be remembered that, when they are changing their skins (that is, every six or seven days during the time they continue in the grub form), if they are disturbed they die; for if they lose hold with the pair of feet at the tip of the tail during the operation, they cannot fix themselves so as to pull themselves out of the old tight skin, and therefore they perish in it.

Prevention.—Some think it a good plan, in order to effect this dislodgment, to draw a very light bush-harrow over the turnip-leaves. When the attack is bad, it is well to delay hoeing. The application in moist weather of nitrogenous or ammoniacal manure, and watering with liquid manure in drought, are measures worthy of attention, it being remembered that a rapid growth is the greatest safeguard against all kinds of insect attack.

Weevils, &c.

In reference to some of the many insect attacks on turnips, Mr John Milne, Mains of Laithers, Aberdeenshire, writes:—

"If the turnip crop is destroyed by the fly (or beetle), harrowing down the drills and re-forming them before resowing will cover and destroy many of the beetles.

"Two varieties of weevil, *Curculio*, are also very destructive to the young turnip plants. They, indeed, sometimes do more mischief than the turnip-beetle. The most destructive one is the little *Curculio, Ceutorhynchus contractus*, one-fourteenth inch long, which punctures the seed-leaves with its rostrum. When approached, it suddenly drops to the ground, draws in its legs and snout, and remains immovable for some time. The *C. as-*

similis, which rears its larva in the turnip seed-pod, attacks the plant also at this early stage.

"No practical remedy has been suggested for the attacks of small weevils, which prey upon the young turnip plants. Reducing the soil to a fine powder prior to drilling, and hard rolling of the drills, will no doubt mitigate their attacks, which are most destructive where the soil is rough and unpulverised. The grain fields should be kept free of charlock, as both the turnip-beetle and weevil feed upon it as they do upon turnips.

Fig. 396.—*Turnip saw-fly grub at work.*

"The most effective remedy for the nigger caterpillars of the saw-fly is poultry, which should be turned into the infected fields, in as large numbers as possible. Rooks and some other birds, as well as pigs, will devour the larva. Brushing them off the leaves, then stamping and covering them, have been tried with more or less success. Cutting ditches may help to circumscribe their attacks. Thunderstorms are said to sometimes kill them.

"To mitigate the attacks of the turnip *Aphis*, man is almost powerless. They possess such extraordinary fecundity that their increase is amazing."

Mr George Brown, Watten Mains, Caithness, referring to the weevils which attack turnip plants, says: "The weevils are small and black. They fix on the under side of the cotyledons or seed-leaves, which are quickly eaten off, leaving nothing but the stalk. In some years, fields are totally cleared by this insect. In one instance I sowed a field of 20 acres three times before getting the turnips into the rough leaf. The second sowing was literally blackened by myriads of weevils. The copper-lime cure would have saved the first sowing."

As to the turnip saw-fly, Mr Brown remarks that "these are not easily dislodged. They are the worst enemies we have to contend with. Attacks are rare, but, when they do occur, no practical remedy is as yet known."

General Observations.

The above short observations are given by no means as a manual of reference. They form only a very brief record (with the assistance of the figures) of what are some of our chief insect pests, and of various measures which are applicable for prevention, or for lessening the amount of their ravages.

One great point needed to help agriculturists in fighting against farm insect pests, is that they should have information at hand, or be able to gain it by reference, as to the whole history of the destructive insect, and thus know at what stage of its life the pest lies most surely under power of prevention.

When the attack is in full progress, it is far more likely than not that any application to check it by attempting destruction of the insects will merely be an additional expense. Manurial or fertilising dressings that will push on a vigorous and rapid growth are our best hope under these circumstances. But some of

the worst attacks, which it is almost impossible to deal with when in possession, may be greatly mitigated by previous measures of cultivation of the land, or of destruction of sheltering rubbish, or sometimes by special dressings.

Where land can be left free for a sufficient length of time to turn the application to a safe and serviceable manure, dressings of gas-lime, which in caustic state is poisonous alike to insect and vegetable life, are of great service.

The careful dragging and burning of stubble, couch grass, and rubbish generally from the surface of the field harvested in autumn, would in itself destroy many pests; and all measures to secure good growth are amongst the best preventives of damage from attacks of the crop insects which more or less are sure to occur, together with the crops they feed on.

Mr George Brown, Watten Mains, Caithness, who has given much attention to the combating of insect pests in farm crops, writes: "Insect attack is most serious at the most critical period of the growth of the plants—that is, when the plant has exhausted the food-supply of the seed, and is becoming dependent upon the soil. From this we infer that plenty of food in a readily available form, within easy reach of the plant at this juncture, will, as a rule, be the best remedy. But the difficulty often is to detect an attack before the ravages become too apparent. For this very close observation will be necessary.

"Climatic influences have everything to do with the life-history of insects. A certain amount of heat is necessary for their development into the larva. Now I have observed that if we have very warm weather when the turnip seed is being sown, followed by a spell of cold weather, we are certain to have our turnips seriously attacked by the fly and weevils. It is the same with the grub, *Tipula oleracea*. I fancy the warm weather so hastens the development of the insect embryos that they become contemporaneous with the braird in its early stages, and then, when cold weather sets in, the plants are checked in their growth, and thus fall a ready prey to their insect enemies.

"Unfortunately, most of the remedial measures which have been recommended, although they may have been found effective on a small scale, are not quite practicable where large fields have to be dealt with. In other cases, the cost of application under former conditions was greater than the farmer cared to face. Now, however, we are all hopeful that that most ingenious machine, the 'Strawsoniser,' may lift us out of our difficulties, and enable us to effectually, and at moderate cost, do battle with most of the insect enemies of our crops. For turnip-fly or weevil, a solution of 6 lb. sulphate of copper, 6 lb. caustic lime in 100 lb. of water, sprayed by the 'Strawsoniser' over an acre, would seem to be the best and most practicable remedy. Paraffin is also useful. In all probability it will, in the near future, become a recognised farm practice to send the 'Strawsoniser' over a crop suffering from an insect attack."

Literature on Farm Insects.—For those who wish to study the prevention of crop insects *in extenso*, there is much excellent information available in the papers by John Curtis, published in the early numbers of the *Journal of the Royal Agricultural Society of England*, and also procurable in collective form in the volume entitled *Farm Insects*, by John Curtis, a work that contains many excellent illustrations, several of which the publishers, Messrs Blackie & Sons, have kindly permitted us to use here.

The reports on "Injurious Insects of Great Britain," prepared for the Agricultural Department by Mr Charles Whitehead, give an immense mass of useful information in plain wording, with plentiful illustration, and at the cost of a few pence for each report. In the *Manual of Injurious Insects*, a single octavo volume, and in the yearly Reports of Miss Ormerod, the Consulting Entomologist of the Royal Agricultural Society of England, there is much useful information, these reports being especially contributed from agriculturists of practical as well as scientific observation.

For those who wish to study the subject of injurious insect prevention in other countries, the Reports of the Entomological Society of Ontario, published

yearly by order of the Canadian Parliament, may be mentioned as embodying excellent information, both scientific and practical.

The same remarks apply to a great extent to many of the Reports of the Department of Agriculture, and of the State Entomologists of various of the States of America. In these, however, the scientific entomological information is often given in such full detail and technical phraseology as to make them of little service excepting to trained entomologists.

For those who are disposed to pursue the subject into another language, the German work, *Die praktische Insekten Kunde*, by Professor E. L. Taschenberg, in five parts, may be commended. This work, indeed, has perhaps no equal for sound information both on the practical and entomological bearing of the subject. It lays before the reader not only the life-histories of the insects referred to, but also descriptions of them in every stage, besides giving beautiful illustrations of many kinds. It also enters at length into methods of prevention and remedy.

FUNGOID ATTACKS ON CROPS.

Farm crops are unfortunately subject to injury from the attacks of vegetable as well as animal enemies. The number of fungi known to attack and live upon the cultivated crops of the farm is almost countless. Some of them are comparatively harmless; others are exceedingly destructive.

We cannot here attempt anything like a full account of the many fungoid attacks to which crops are liable. We deal at considerable length with two of the most destructive, club-root or anbury in turnips (*Plasmodiophora brassicæ*, Wor.), and the potato disease (*Peronospora infestans*, Mont.) A few others we will refer to briefly. Those who desire to study fully the life-history of the various fungi which prey upon farm and garden crops may, with advantage, consult some specialist work, such as Mr Worthington G. Smith's admirable volume, entitled *Diseases of Field and Garden Crops*, published by Macmillan & Co.

CORN MILDEW.

This is a prevalent and very destructive disease, arising in different forms and from various causes. The "spring rust and mildew" is one form, known early in the season as rust, when it is seen in the form of reddish spots on the stems and leaves, and later in the season as "mildew," when it shows itself in black spots. It is, however, practically one disease, due to the attacks of the same parasitic fungus, *Puccinia rubigovera*, D.C.

This fungus appears very early in April or May, or even in March, and absorbs the substance which should go to the production of the ears of grain. The growth of the corn is thus impaired, and a deficient crop is the result. The straw as well as the grain is injured, and in the former the disease is carried on from the one season to the other.

Summer rust and mildew is another and more destructive form. It is caused by the fungus known as *Puccinia graminis*, Pers. It is usually first seen in June and July, and often reduces the crop by from 30 to 50 per cent or even more.

Corn Mildew and Barberry Blight.—As to the life-course of this destructive fungus there is a sharp division amongst botanists. Many leading botanists and others believe and contend that the germs of the fungus must pass through, or, as Mr W. G. Smith puts it, be "nursed by a barberry bush" in spring before they can successfully attack the corn crop. Mr W. G. Smith is a vigorous exponent of the other school, which maintains that there is no necessary connection between the *corn mildew* and the *barberry blight;* that the fungi are perennial; and that both can live on from year to year for an indefinite period without aid from each other. Mr Smith assuredly seems to have won the battle, and the practical significance of this conclusion is that the destruction of the "barberry bush" will not contribute to the prevention of corn mildew.

Corn Mildew Hereditary.—There would seem to be no doubt that the mildew is hereditary in corn—that, as Mr W. G. Smith puts it, "it exists in a finely attenuated state in seeds taken

from diseased plants, and can be transmitted in a long interminable line from generation to generation."

Means of Prevention.

In discussing the means of preventing attacks of corn mildew, Mr W. G. Smith says:[1]—

"All low-lying lands suffer most from mildew, and it is said that elevated lands are next most seriously affected, the intermediate positions being generally most free. This fact is generally explained by the presence of mists in the low lands, and clouds on the hill-tops, the mists and clouds being especially favourable to the development of *Puccinia*. Mildew is commonly seen at its worst in places where bushes and trees abound, as these objects impede free currents of air and aid fungus growth.

"We have ourselves observed corn mildew to develop with great rapidity after rain in August, and we have sometimes noticed the late sown wheat to be most affected. When the ears are badly attacked the grain is not only greatly impoverished and reduced to "skeleton grain," but it is hardly possible to separate the seed from the husks.

"Mildew is said to be more frequent after crops of clover than after other crops. We think the fact of straw from stables being so frequently thrown over old clover fields a sufficient explanation of this fact. Wheat after clover is certainly a favourable alternation of crops with many farmers,—perhaps because the old decaying clover roots act as good manure for the corn. When clover precedes corn it should be heavily folded with sheep, and straw from stables should not be used as manure.

"It is now generally accepted as a fact amongst practical men that after dressing the land with farmyard manure and nitrate of soda, mildew often puts in a strong appearance; but after mineral manures, bone superphosphate, and bone-meal drilled with the seed, rust and mildew are much less apparent. There can be no doubt that farmyard manure has a tendency to produce a gross soft growth in corn which is suitable for fungi, and that mineral manures, on the contrary, have a tendency to produce a firm stiff growth unsuited for rust and mildew. As corn generally does so well in dry limestone and chalky districts, a hint might be derived from this fact as to the desirability, where possible, of manuring land with chalk. We have seen this done with success in North Herts and South Bedfordshire, where chalk is easily obtainable.

"It is probable that the resting-spores of the fungus of corn mildew seldom hibernate through two seasons; therefore, in instances where stable manure must be used, it should if possible be used in the crop preceding the corn or the crop following it rather than for the corn itself.

"An alteration of crops is in every way desirable. Beans, peas, turnips, potatoes, clover, and other farm produce should be taken alternately with corn.

"There is but one way of *getting rid* of corn mildew, and that is certainly not by cutting down barberry bushes and pulling up borage plants. Corn mildew is a *hereditary disease*, and therefore no seed corn should be gathered from mildewed plants. If the hereditary nature of the disease is disputed, it cannot be disputed that certain examples of corn have a strong and inherited predisposition for mildew; therefore predisposed examples should be struck out and no seed gathered from them. Especial care should be taken in the rigorous selection of seed from white wheats, which are notoriously more subject to mildew than red, probably because the latter are naturally more robust. If seed merchants would guarantee that the seed corn they sell is taken solely from corn free from mildew, in the course of years the attacks and consequent losses from this pest would be considerably lessened. Mildew is every year so common in our fields simply, as we think, because the disease is planted with the grain.

"Old corn stubble should not be left too long in the fields. Some corn-growers say that a top-dressing of salt has a tendency to lessen or prevent mildew.

"*Mildewed straw* is bad when used as food for stock in chaff, and the inferior grain is hardly fit for pigs. The straw is more commonly used as litter in stables.

[1] *Dis. of Field and Garden Crops*, 199.

In this position the spores of the *Puccinia* remain uninjured, for neither warmth, frost, wet, or dryness materially affect the vitality of the resting-spores of the fungus of corn mildew. They are so small that no amount of treading from horses, herds, or flocks injures them. The warmth and dampness of the stable floor in every way suits them, and they are frequently taken from this position, full of life, and at once thrown on to the fields in the saturated straw. If the spores are consumed with food by animals, their passage through the alimentary canal does not injure them. The disease is probably, as we think, propagated by the mildewed straw being used as manure, and by the germinating resting-spores of the fungus of corn mildew infecting the first young leaves of the corn.

"Mildewed straw should be destroyed, because the *Puccinia*, with its myriads of resting-spores, is in this material. We have shown that these resting-spores germinate in the spring and early summer at the exact time when rust, which is the early state of mildew, first appears. Whether the resting-spores attack barberry bushes, or whether they do not, is of no great importance, for there are generally no barberry bushes to attack. The mildewed straw should, as far as practicable, be destroyed, and the hedges kept clear of rusted and mildewed grasses."

BUNT OF WHEAT.

This disease is caused by the fungus, *Tilletia caries*, Tul. The diseased grains may not be readily observed, but, when examined closely, they are seen to be unusually short and thick, and are found to contain a black powder with an offensive odour.

Prevention.—The spores of the fungus causing bunt are sown with the seed, and germinate after they have been lodged in the damp ground. The best method of prevention, then, is to treat the seed before sowing, so as to kill the germs of the fungus. This should be done without fail, if there has been bunt in the crop from which the seed is selected.

Disinfecting Seed.—As to the means of disinfecting wheat seed, Mr W. G. Smith says:[1]—

"When bunt is known to be amongst seed grain it should be washed or steeped in some weak poisonous solution, as the minute spores from bunted grains adhere to the healthy seeds. Water, salt, quicklime slacked with boiling water, sulphate of copper, a quarter of a pound to a bushel of corn, and sulphate of soda, have all been recommended. Sulphate of soda in solution and the seeds afterwards dried with dusted quicklime is said to be one of the best preventive solutions. The lime combines with the soda and forms sulphate of lime or gypsum, whilst caustic alkali is set free. As the spores are lighter than water, mere steeping in brine or even pure water is often effectual, as the spores float, and are easily washed away. It is probable that the presence of a few scattered greasy spores are quite as, if not more, damaging than the whole bunted grains with unbroken seed-coats. Some alkaline ley should be added if water is used, as the oil on the surface of the spores combines with the alkali and forms a soapy substance which is fatal to effectual spore germination. Sufficient permanganate of potassium may be added to the water until it becomes rose-coloured, or one per cent of carbolic acid may be mixed with the water. It is not proper for the seed to remain long in these solutions; they should be washed quickly and then allowed to dry.

"When millers see bunted grains amongst the wheat they generally pass it through a dresser with a strong exhaust, and this draws away the fœtid spores."

SMUT OF CORN.

This is a fungoid disease, too well known to need description. It is caused by the fungus, *Ustilago carbo*, Tul. When attacked, the grain is entirely destroyed, crumbling away in the form of a fine black or dark-brown powder. It attacks wheat and barley, as well as oats, but is most destructive in oats, not unfrequently blasting one-third or more of the crop.

[1] *Dis. of Field and Garden Crops*, 252.

Propagation of Smut.—Mr W. G. Smith states that the disease is doubtlessly propagated by the spores of the fungus being blown over the fields and absorbed by the earth, and by the fungus spores which adhere to the seed at the time of sowing. He considers the evidence complete that the infection comes from the ground, and travels upwards.

Prevention.—As to the prevention of smut, Mr W. G. Smith says:—

"It is obvious, therefore, that smut can only be prevented by dressing the seed, as in the case of bunt, and the directions for one apply to the other.

"A remedy against smut, much in favour in the north of England, and one which is said never to fail, is the preparation of the seed, immediately before sowing, with a sprinkling of stale urine, the seeds being afterwards raked in powdered quicklime till the seed is white. Sometimes the seed is prepared with vitriol or sulphate of copper solution, or 'bluestone' dissolved in boiling water. One pound of 'bluestone' dissolved in 5 quarts of water is sufficient for a sack of 4 imperial bushels. The seed is soaked for ten minutes, or the 10 pints of solution may be poured over till all is absorbed."[1]

FUNGOID ATTACKS ON CLOVER.

It is well known that clover is attacked and injured by mildew caused by fungi, notably two forms of *Peronospora*—namely, *trifoliorum*, D.By. and *exigua*, W.Sm. The part which these fungi may play in the so-called "clover sickness" is uncertain, but there can be no doubt that they often cause considerable damage to clover.

These fungi are favoured by bad drainage and the absence of free ventilation, such as is sometimes caused by over-thick sowing. The germs pass the winter in the stems of clover, and a useful method of prevention is to cut and burn all dead and decaying clover material.

Clover Dodder.—The clover dodder, *Cuscuta trifolii*, Bab., is a troublesome parasitic plant, which, with its thread-like stems, entwines itself around the clover plants, absorbing the substance therefrom.

The dodder seed is imported with clover seed. It is therefore necessary that great care should be exercised on the part of the seedsman to sift out any dodder seed before supplying the farmer. The seed of the dodder rarely ripens in the British Isles, but it is recommended that dodder plants should be carefully pulled up and destroyed, and not allowed to rot on the ground—this, because it is believed the thread-like stems are sometimes perennial.

Mr W. G. Smith mentions that some farmers, on first seeing the yellow patches of dodder in the clover fields, remove all the clover from the outer edges of the invaded patch for a width of about 18 inches. This leaves nothing for the dodder to prey upon, as the thread-like stems cannot stretch across the 18 inches of vacant ground. The clover is removed because it is extremely difficult to entirely remove dodder.

POTATO DISEASE.

The potato crop gives little trouble early in summer. As the season advances, however, the extensive grower of potatoes watches his potato-break with uncomfortable anxiety. He is looking for that unwelcome visitor, *Peronospora infestans*, by whose depredations British farmers have sustained enormous losses.

Cause.—The particular "potato disease" which we are now considering, and which has proved so serious as to throw minor ailments into the shade, is the work of a fungus, now generally recognised as *Peronospora infestans*, Mont.

This fungus makes its appearance on the potato-leaves towards the end of July, and during the months of August and September. It is seldom observed in this country before the end of the third week in July.

Weather and the Disease.—The fungus generally appears during close weather, with a humid atmosphere, especially when mists hang over the fields in the evenings and mornings, and the days are hot and damp. These are conditions well known to favour fungoid growth, and never fail to increase the seasonable anxiety of the potato-grower.

[1] *Dis. of Field and Garden Crops*, 261.

Recognising the Fungus.—The fungus, as a rule, first attacks the leaves, and any measures taken to prevent it from reaching the tubers will be more effective if promptly adopted. It is therefore important that farmers should be able to at once recognise the fungus when it makes its appearance. "The fungus," says Mr Worthington G. Smith, "generally manifests itself to the less experienced observer as a fine white bloom on the leaves, accompanied by dark putrid spots. The bloom is sometimes more profuse on the lowermost leaves of potato plants, not because the fungus has travelled up the stem from the seed tuber, but because the air is more moist and stagnant near the ground. The bloom, with its accompanying black disease blotches, soon travels to the stems, and when at length the tubers are reached, the exhausted seed tuber (the weakest part of the plant) is commonly traversed in every part by the spawn of the fungus. During warm, humid conditions of the weather, the black decomposed spots are sometimes present for several days on the leaves before the fungus is seen. These blotches indicate that the putrefactive spawn of the fungus is within the leaves, awaiting favourable conditions for its complete development as a white bloom outside. The phenomena just mentioned are accompanied by a peculiar and very offensive odour well known to every person who has walked through a field of potatoes suffering from disease. The odour is caused by the putrescence set up in the tissues of the host plant by the contact of the mycelium of the potato fungus. Although the attack of disease in potato plants is apparently sudden, and made on apparently sound plants, yet all known facts point to the probability of the existence of the fungus in a nascent state during at least several weeks prior to its general recognition. The belief in the extreme suddenness of fungoid growths is, in many instances, a mere popular delusion." [1]

The Fungus in its Active State.

As to the structure and mode of growth of this remarkable fungus, it will be interesting and useful for farmers to peruse the following extracts from Mr Worthington G. Smith's admirable little volume on the *Diseases of Field and Garden Crops* (Macmillan & Co.):—

"For an exact examination of *Peronospora infestans*, Mont., a very minute and extremely thin and transparent slice must be cut from a diseased leaf at a spot where the white bloom caused by the presence of the fungus is visible underneath. A good plan is to cut a diseased leaf in two through a disease spot, and then with a sharp lancet cut an extremely thin slice off from one of the exposed cut surfaces. If the slice last cut is somewhat longitudinally wedge-shaped, it will often best show the structure of the leaf and the contained fungus at the thinner end of the section. Such slicing requires great care and experience, and the art is only acquired after many failures. The atom to be examined should be placed on a glass slide in a drop of glycerine (this is preferable to water, as the latter often dries too quickly), and then covered with a clean thin cover-glass.

"The magnification given by an ordinary lens is useless for the observation of the minute fungus now before us, so we must at once place it under the higher powers of the microscope. If the slicing through a disease spot is successful, we shall probably see the atom when magnified 100 diameters, as at fig. 397. The thickness of the lamina of the leaf is shown at A, B; the under side of the leaf is represented at A, from which surface the fungus almost invariably springs. The fungus, therefore, really grows downwards. The true upper surface is shown at B. This reversal of the leaf in the illustration is merely, as in other instances in this book, to show more clearly the tree-like branching growth of the fungus. If we confine our attention for the present to the section of the leaf, we shall note that it is made up of minute bladder-like cells, loosely packed together; and that the cells at top and bottom, representing the lower and upper cuticle of the leaf, are devoid of the shading, which is meant to indicate the green colouring matter or chlorophyll within. An opening into the interior of the leaf will be seen at C; this is one of the stomata or organs of transpiration,

[1] *Dis. of Field and Garden Crops*, 279.

sometimes referred to as 'breathing pores.' The stomata are like the gates to a camp or to an intrenched position; they are the weak points through which an enemy may enter, and when once these gates are passed, the whole interior of the plant is at the mercy of the invader. At D may be seen a hair built up of four transparent cells, the two lower being traversed by a mycelial thread of the potato fungus. On the upper part of this hair, attached to the outside at E, may be seen one of the small branches of the fungus; this branch has burst and thrown out a mycelial thread from its side. Every fragment of the potato fungus is capable of growth, and of ultimately reproducing the parent fungus. The cells immediately under the true upper cuticle of the leaf at F are termed palisade cells; and their disposition in the manner illustrated serves to give the necessary firmness to the exposed upper surface of the leaf.

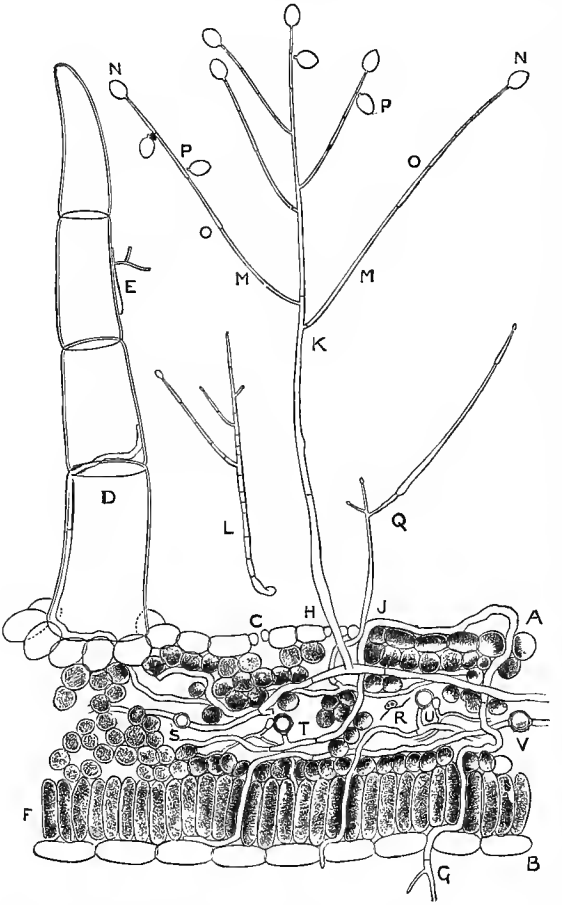


Fig. 397.—*Section through a fragment of a potato-leaf, with the potato fungus,* Peronospora infestans, *growing within its substance, and emerging through the epidermis. Enlarged* 100 *diameters.*

"If we now look within the fragment of the leaf we see transparent threads running between the small spherical leaf-cells; these are the spawn-threads or mycelium of the fungus. It should be especially noticed that wherever the spawn touches the cells it discolours them (as indicated by the darker shading), and causes putrescence by contact. If we again look at the palisade cells near G, we observe that a spawn-thread has pushed itself between them and between the cells of the upper cuticle, and is emerging into the air. If we trace the spawn-threads to the organ of transpiration at H, we notice that a thread in its passage from the body of the leaf has blocked up a so-called mouth. This choking prevents the transpiration of vapour, and hastens putrescence. Two other threads have pushed themselves between the leaf-cells at G and A. When the larger of the emerged threads is traced upwards to K, a tree-like growth is noticed; and this branching form is the fruiting condition of the fungus of the potato disease called *Peronospora infestans*, Mont. The whole fungus is perfectly transparent, like colourless glass, and extremely fine, thin, and attenuated in all its parts. If we now look at the branches, M M, we observe that each is surmounted by a transparent spore, technically termed (as in other species

of *Peronospora*) a conidium, as at NN; and to these bodies we shall more specially refer further on. It must also be noticed that all the branches are more or less constricted or jointed in a peculiar manner, as at O O; and that each joint has at one time carried a conidium, the lower conidia having been pushed off as the branches have continued their growth, as at P P. Sometimes a weakly impoverished thread, if grown in dry air, will quickly become strong and robust in growth if transferred to warm moist air, as in the thread illustrated at Q.

"If ripe conidia [N N] are placed in water, it will be noted that a differentiation of the contained protoplasm takes place; and that the interior mass of each conidium becomes divided into from five to nine or more portions, each contained portion being furnished with one or two lustrous vacuoles. These differentiated portions speedily emerge from the top of the conidium when placed on any moist surface; and each portion now free, becomes quickly furnished with two extremely fine hairlike cilia, tails, or vibrating hairs. These secondary spores or zoospores are able to sail about in the slightest film of moisture. After a brief time the little motile zoospores or animal-like spores rest and take a globular form, and the vibrating hairs dissolve away or drop into the finest dust. After a short rest the now quiescent zoospores burst and produce a thread of spawn; this germinal thread is capable of carrying on the existence of the potato fungus.

"Sometimes the conidium, which, when it bears zoospores, is really a sort of spore-case, sporangium or zoosporangium, does not differentiate within, but bursts and protrudes a small mass of protoplasm or vital material. This mass speedily elongates into a mycelial thread capable (like the thread from the zoospore) of carrying on the life of the potato fungus. It must be specially noted that water or moist air is essential for the existence of the fungus, for nearly every part speedily perishes in dry air, heat, or frost. When the conidia burst and set free the minute zoospores, the latter sail over the damp surfaces of leaves, and even float into the organs of transpiration. A zoospore swimming in an intercellular space is shown at R, fig. 397.

"One has only to imagine a large field of potatoes, with all the leaves moist and swaying backwards and forwards with the wind, to perceive that such a field, say on a warm misty morning or evening, would form a sort of continuous lake of moisture on which the zoospores could float from one plant to another. The conidia, with the contained zoospores, are also carried through the air in millions by the wind; they are so lightly attached to their supporting stems and so extremely small and light, that the faintest breath of air wafts them away. Insects and other creatures also carry the conidia from place to place. The flies which alight on potato plants carry off hundreds of conidia on their bodies. If a bird drops in a field of diseased potatoes, the fluttering of its wings will disperse millions of the conidia of the fungus of the potato murrain into the air. The same phenomenon occurs when a dog or other animal runs amongst diseased potato plants. When the conidia or zoospores burst and germinate, the threads which emerge are corrosive or putrefactive. To such an extent is this the case that the spawn is said to be capable of piercing or boring through the cuticle of the leaf from within or without, regardless of the natural openings or stomata, and even of piercing the bark of the stem or the tuber itself.

"The fungus of the potato disease generally attacks the leaves first, and, as the leaves produce successive crops of fungus growth, the disease quickly spreads to the leaf-stalks, from the leaf-stalks to the chief stems, and from the stems to the tuber. Sometimes a week or two elapses before the tubers are reached by the putrefactive spawn of the fungus; but in other instances the attack is so sudden and so highly destructive, that the whole of the potato plants above ground in a large field will be destroyed in a day or two. The disease doubtlessly starts at first from a few centres only; there it remains for a brief time more or less unobserved. The fungus, however, possesses such wonderful powers of spore production and rapid growth, especially when the air is moist and the temperature ranges from 60° to 70° Fahr., that in a few days one fungus growth will become ten thousand. This growth goes

on in a constantly increasing *ratio* until at length the great flood of disease seems to almost suddenly cover the potato fields.

"When the fungus spawn reaches the tuber it decomposes the cells and corrodes the starch. In bad cases the tubers are soon reduced to a mass of putrefaction."

How the Fungus passes the Winter.

Perhaps the most formidable hindrance to a successful warfare against the potato disease is the peculiar provision which enables the fungus to pass through the winter in minute resting-spores, ready to pounce upon the crop in the following year, should the weather and other circumstances favour the development and attack of these mysterious germs of fungoid life.

The fungus having attacked the leaves of the potato, and found its way down the stem to the tubers there, runs through the course which Mr W. G. Smith has so graphically described. Having finished that course, it produces myriads of resting-spores which lie dormant during the winter, and carry on the disease to the crop of the succeeding year, which in its turn passes the fungus through another round of its destructive life, to be handed on again to a succeeding crop as before.

Mr Worthington G. Smith describes the course of these resting-spores very minutely; and we have to thank him for his permission to reproduce here, besides the illustration already given on page 419, a drawing made by himself of a section of an old potato leaf showing the resting-spores. In referring to the resting-spores Mr Smith says:—

"We will now leave the potato fungus as seen in a living potato-leaf and take a fragment of a dead leaf, one that has been destroyed by the *Peronospora*, such as may be seen in fields and gardens in September, or, if preserved with care, such as may be kept on a garden-bed till the following June. A fragment of such a potato-leaf is illustrated in fig. 398, enlarged, like fig. 397, to 100 diameters. The upper surface of the leaf is shown at A, the lower surface with two stomata at B B, and a small hair belonging to the leaf is seen at C. Nearly all the mycelium of the potato fungus has vanished; fragment only, in a hibernating, septate state, is seen at D. The transparent oogonia of the summer have now become brownish ripe oospores or winter resting-spores of a larger size. Six resting-spores are shown in the illustration,—two in the transparent leaf hair, three in the intercellular spaces of the leaf, and one inside a spiral vessel, in which position it is extremely common to find them.

"The perfectly mature resting-spores are best seen in the remains of old rotten tubers left in the fields from the previous year, and commonly seen on the ground and about dung-heaps and hedge-sides in March and April.

"On an examination of a large number of resting-spores it will be found that

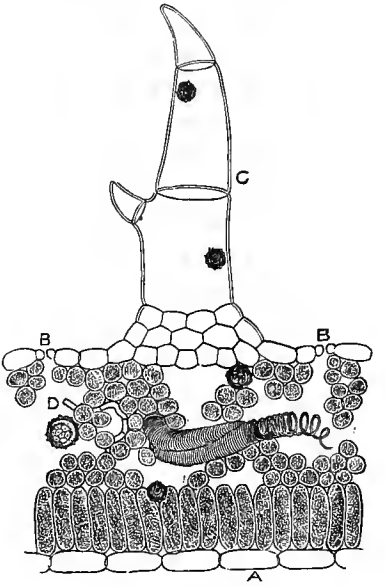


Fig. 398.—*Section through a fragment of old potato-leaf, with resting-spores or oospores of* Peronospora infestans, in situ. *Enlarged* 100 *diameters.*

the convolute mass of protoplasm within, though generally in one coil, may at times be in two or even three distinct portions, which, on germination, will produce one, two, or three germ-tubes; in other instances the interior mass becomes differentiated into zoospores, which escape, and speedily come to rest and germinate; the germinal threads from oospores and zoospores alike, when placed either on the foliage or tubers of potatoes

and kept uniformly moist and warm, soon give rise to the fungus of the potato disease, and cause discoloured patches of decomposition as the growth proceeds.

"Every part of the fungus, except the oospores, generally perishes with the supporting plant; the oospores or resting-spores are left alive upon or in the ground where potato material has decayed, and in this position the oospores germinate in June and produce the first conidia of the season. Such of the conidia as are blown from the ground or from decaying potato refuse on to potato plants, or certain allied plants, produce disease; such as fall in unsuitable positions perish. The progress of the disease is, therefore, necessarily at first extremely slow: it only progresses with rapidity after the living potato plants are thoroughly invaded.

"We have secured potato oospores direct from the ground by observing water filtered through earth on which diseased potato material has been allowed to decay.

"The fungus has attacked the leaves and proceeded downwards by the stems into the seed tuber from which the plant originally arose, and there, having run its course, it has produced resting-spores for the invasion of the following year's crop of potatoes. It is much less common to find resting-spores in the hard new tubers even when discoloured by disease; still it is quite possible to find them even in new potatoes. Ripe resting-spores of the potato fungus may be found with great ease in the spring and early summer, in the fragments of diseased and decayed potatoes picked up in the fields or about manure and refuse heaps by hedge-sides.

"A germinating resting-spore may be compared with a germinating seed of dodder. The dodder has enough nourishing material stored up within its outer integument to support an infant dodder plant for a short time. If no suitable host plant is near, the young dodder perishes. The first fruiting branch from a germinating resting-spore of the potato fungus is in an exactly similar condition, for, unless the spores or conidia are aided by the wind to reach a potato or some other suitable plant, the first-produced conidia perish at once. The resting-spores of the potato fungus germinate in and upon the ground at the precise time of the year when the potato plant is in the best condition for infection. Habits of this nature are extremely common and well known amongst parasitic fungi."

REMEDIAL MEASURES.

Cure.—There is practically no cure. An attack of the fungus may be partially or entirely averted or checked, but an injury once inflicted cannot be repaired.

Preventive Measures.—The measures which have been found most useful in preventing or mitigating the onslaught of the fungus are—(1) earthing up the potato-drills with a deep covering of earth, with the view of preventing the fungus from passing down the stem or through the soil to the tubers; (2) cutting off the diseased potato-tops before the fungus reaches the tubers; (3) removing and destroying (burning) all dead and decaying potato-stems, leaves, and tubers, especially after a crop which has been attacked by the disease; (4) planting varieties which have been known to be exceptionally successful in resisting the disease; (5) growing the potato crop under such general sanitary and manurial conditions as will ensure to the fullest extent possible the healthy and vigorous development of the crop; and (6) careful storing of potatoes to be used as seed.

None of these measures could be regarded as an absolute remedy, but in certain cases each and all have been carried out with manifest advantage.

Protective Moulding.

This method is known generally as the Jensen system, from the fact that Mr J. L. Jensen of Copenhagen was, with the aid of Mr C. B. Plowright, M.R.C.V.S., King's Lynn, mainly instrumental in bringing it into public notice. It consists in earthing up the potato-drills with a deep furrow, so as to have about 5 inches of earth over the uppermost tubers, and thus tend to prevent the mycelium of the fungus from reaching the tubers from the leaves through the soil—the stems and leaves of the potatoes being bent to one side, so that the spores

of the fungus may fall from the leaves into the hollow rather than on the top of the drills.

The fungus has in a few instances been found to begin in the tuber and work upwards, but the rule is exactly the reverse. Development in the leaves of the potatoes would seem to be an important condition in the life of the fungus. The object of the Jensen system is therefore to prevent its getting beyond the leaves and stems.

Mr Jensen gives the following as the "principal points" in the protective-moulding system:—

"1. The ground must be thoroughly worked, so that the potatoes may be bedded in well-crumbled earth. Such earth affords a better means of protection than a lumpy soil.

"2. The potatoes should be planted (pretty early) in a distance between the rows of at least 28 or 30 inches. A greater distance is not required by the system, but a smaller distance would impede the protective moulding.

"3. The first moulding must be flat, so that the formed ridge be broad on top and only about 4 inches high. This moulding may be repeated if it is thought serviceable.

"4. The protective moulding must be applied as soon as the disease blotches make their appearance on the leaves of the potato plants. If this has not occurred before wheat-harvest time, the moulding ought to be executed then, without awaiting the appearance of the disease blotches.

"The protective moulding is performed by throwing up from one side of the row of plants a high ridge with a broad base, and running to as sharp a point at the top as possible. The covering of earth thereby produced over the upper surface of the uppermost tubers must be about 5 inches to begin with; later, by the settling of the earth and by sliding down, it will, as a rule, preserve a thickness of about 4 inches. At the time of this moulding the potato-tops are gently bent over towards the opposite side of the row, so as to give the top at least a half-erect position.

"6. The flat and the protective moulding, where potatoes are only grown on a small scale, may be done with a hand-hoe; on a larger scale these operations ought to be performed with the moulding-plough, the "Protector," which is constructed to meet the necessities of the described system.

"7. In order to prevent after-sickness, which may often be exceedingly great, the potatoes must not be lifted ere about three weeks after the last leaves in the potato-field are withered.

"8. If the potato-tops are cut off and carried away, which, for the sake of the quantity and quality of the crop, ought not to be done before the leaves in the main are withered, the lifting may, as it seems, without danger of after-sickness, take place about six days after such removal."

Merits of the System.—This system has been extensively experimented upon in this country, and the results have been somewhat variable. The majority of the experimenters have come to the conclusion that if carried out carefully and at the proper time, immediately the first signs of the disease are observed, it will most likely have the effect of greatly mitigating a serious attack of the disease—reducing the loss by disease in extreme cases, perhaps from 30 to 10 per cent of the entire crop. In other cases again, it has been much less effective. Then in most instances it has been found to have a marked tendency to lessen the yield of fully grown tubers—increasing the percentage of small unmarketable potatoes, so much in many cases as to make the crop unprofitable.

Mr Speir's Experiments.—Mr John Speir, Newton Farm, Glasgow, put the system to a thorough trial, and the results led him to the opinion that by it the disease may be kept within very narrow limits.

His first series of experiments with the system resulted as follows:—

High Moulded.	Percentage of diseased tubers.
15th June	16.04
1st July	12.88
15th July	8.06
1st August	7.25
15th August	9.70
1st September	5.37
6th September (just after disease appeared)	6.55
Moulded in the usual way	24.20
„ very flat	31.00
Bent tops, with the high moulding at various times	7.68
Tops not bent	10.54

These results were obtained in drills 30 inches wide. But he also experimented with the system in drills of various widths, from 24 to 30 inches wide, finding that by far the best crop with least disease was obtained from high moulding on 30-inch drills. Upon 24-inch drills, the results of the high moulding were unsatisfactory. This corresponds with the experience of others, who have found that in a narrow drill with a sharp apex, numerous potatoes are liable to be "greened" by coming so near to the surface.

Other Experiments.—Results quite as favourable to high moulding as in the trials made by Mr Speir were obtained in the south-east of Scotland by Mr S. D. Shirreff, North Berwick, Mr H. Elder, East Bearford, and others. On the other hand, at Barneymains, near Edinburgh, Mr John Durie found that while the high moulding lessened the disease by a small percentage, it incurred an actual loss on the crop by reducing the yield of marketable potatoes.[1]

Bending the Tops.—The bending of the potato-tops to one side of the drill no doubt tends to lessen the disease, but it is also liable to reduce the yield of the crop. If done roughly, so as to break or bruise the stem, the development of the tubers will be seriously interfered with. If done at all, the bending of the tops must be performed with great care and very tenderly. It is almost impracticable where large areas of potatoes are grown.

The System little Practised.—Although there would seem to be certain merits in the protective moulding—although it would seem to be the most effective method yet known of repelling or lessening a threatened serious attack of the disease—the fact remains that the system has never come into general use throughout the country. A few, but only a few, persevere with it, and while there are a good many farmers who speak well of it, it does not seem to be gaining ground. It is probably most effective in repelling an attack of the disease which occurs late in the season—that is, after the crop has approached its full growth. In this case, of course, injury to the tops would not tell so seriously upon the yield as if it occurred earlier in the season.

[1] *N. B. Agriculturist*, 1882 and 1883.

The Main Difficulty.—The main difficulty in late moulding is the rankness of the potato-tops. These are often so rank that it would be almost impossible to have the earthing up accomplished without great injury to them. On this account alone many who have tried the system and acknowledge its efficiency have abandoned it as impracticable.

As a means of obviating this difficulty of injuring the tops in late earthing up it has been recommended—(1) that the potato-drills should be unusually wide, not under 30 inches; or (2) that between every two drills of potatoes there should be two, four, or more drills of roots, mangels or turnips. The latter method would be most advantageous to the potatoes, but in working it would rarely be practicable—that is, where potatoes are grown to any great extent.

Upon the whole, we have no hesitation in recommending that where it can be done without serious injury to the potato-tops, the protective moulding should be resorted to whenever an attack of the disease is observed.

High Moulding Plough.—The Jenson or "Protector" plough is designed specially for the high moulding. The work may be done, however, by an ordinary drill or single-furrow plough, provided with an unusually deep mould for throwing the earth on to the top of the drill.

Antiquity of the System.—The system of high moulding was not "invented" by Mr Jensen, as has been sometimes stated. It was practised by a few English potato-growers about 1850, and was described by Dr Jeffrey Lang in the *Journal of the Royal Agricultural Society of England* for 1858. Dr Lang remarks that "it was observed that no potato covered with more than 3 inches of soil was ever diseased. . . . It will at once be seen—and too much stress cannot be laid on the fact—that the disease is in exact ratio to the proximity of the tubers to the surface."

Then, as now, the practical difficulty of carrying out the work successfully would seem to have prevented its extensive adoption.

Cutting off the Tops.

Since it is generally the case that the disease begins on the leaves and passes

down the stems to the tubers, it follows that the tubers might be protected from it by the leaves and stems being cut off and removed as soon as the fungus is observed upon them.

This, indeed, is a speedy and effective method of combating the fungus. But the remedy may be worse than the disease. The removal of the stems and leaves at once stops the development of the tubers. The starch of which the potato is so largely composed is first formed in the leaves. If, therefore, the leaves are removed before the tubers are ripe, the result must be a deficient crop.

It is thus only as a last resort—where an immature, deficient crop would be better than the crop likely to be left by the disease, if allowed to take its course—that this drastic measure should be adopted.

As a further precaution, when the leaves and stems are cut off, it has been recommended that the cut ends of the stems should be sprinkled with dry lime.

Disease-resisting Varieties.

It is known that certain varieties are, for the time being, exceptionally successful in resisting the attacks of the fungus. This valuable property is most generally found in some comparatively new variety—a variety recently raised from the seed, perhaps by cross-fertilisation, as described in pp. 276-280 of this volume—whose constitution and vitality of growth are unusually robust.

It is obviously advantageous therefore, as a means of guarding against loss from the disease, to plant for the main crop such varieties as are at the time known to be the most successful in resisting the onslaught of the fungus.

Unfortunately there is a tendency in all the cultivated varieties of potatoes to lose vitality with long-continued culture. The "Champion," for instance, which for many years was almost disease-proof, at last fell an easy prey to the fungus. It is therefore desirable that the propagating of new and robust varieties should be liberally encouraged by potato-growers. See pp. 276-280 of this volume.

Conditions of Culture.

The liability (or the opposite) of the potato to injury from an attack of the fungus may be powerfully influenced by the conditions under which the crop is cultivated. It may be accepted as a general rule, that whatever tends to retard the healthy growth or weaken the vitality of the plant assists the fungus in its onslaught.

Humidity necessary for the Fungus.—As with most forms of fungi, it is necessary for the preservation and propagation of the potato fungus, *Peronospora infestans*, that a considerable amount of moisture should be present. Indeed, we have it on the highest authority that nearly every part of the fungus in the active state (that is, apart from the condition of the resting-spore in which it lives through the winter) speedily perishes in dry air, heat, or frost. In the form of the zoospores, or resting-spores as they are aptly termed, the germ of the fungus will survive through the hazards of the winter. But for its fructification and free propagation on the potato plants in the following season, a considerable amount of moisture on and around the potato plants would seem to be quite essential.

Dry Elevated Land for Potatoes.—The practical lesson to be drawn from this is, that potatoes should, as far as possible, be grown upon well-drained land, in a dry, elevated, bracing position. Low-lying swampy ground, subject to mists, is, on this account, particularly ill suited for potatoes. It is well known that the disease is most liable to break out and do serious mischief during close humid weather when mists envelop the fields morning and evening.

It will often be beyond the power of the farmer to avert these conditions. He can, however, do a good deal in this direction—mainly by avoiding low-lying ill-drained land with his potatoes, and planting them on dry exposed land.

Sunshine and Dry Winds.—Bright sunshine and dry hot winds are destructive to the fungus. It is therefore useful to have the potato-drills wide apart, and set so that the noonday sun may have full play amongst the tops.

Manure.—In manuring, as in other matters connected with the culture of potatoes, it is important that the crops should be treated so as to secure as robust and steady growth as possible. Imper-

fectly balanced manure will tend to produce plants which are constitutionally weak. See therefore that the crop has all that it requires of the various elements of plant-food.

The decaying of rank dung in the soil is favourable to fungoid life. Well-rotted dung is for this reason preferable to fresh dung for potatoes. And artificial manure affords less encouragement to the fungus than dung, with its bulk of putrefying vegetable matter.

As with the human family, so with plants—the best safeguard from disease is healthy food and healthy sanitary surroundings.

Destroying Potato Refuse.

One of the most essential and effective precautions against future outbreaks of the disease is to gather and destroy all potato refuse—leaves, stems, and rotten tubers—that may be left on the field when the crop has been harvested. In all probability, if disease had attacked the crop, this refuse will be swarming with the germs of the disease.

To gather this infested rubbish to the dung-heap is absolutely nursing the enemy—keeping it warm and vigorous for future attacks. Burn the potato refuse, if convenient; if not convenient, bury it beneath the reach of the tillage implements. "No more fatal mistake," says Mr W. G. Smith, "can be made by potato-growers than leaving dead stems, leaves, and tubers about in their fields, especially after a potato crop has suffered from disease."

Care of Potato Seed.

The seed to be planted should not only be selected from disease-resisting varieties, but have been stored in conditions antagonistic to the life of the germs of the fungus. Upon this point Mr W. G. Smith writes: "Sometimes growers keep their potatoes in enormous underground heaps, called 'pies' [or pits]; in these positions the tubers frequently heat and rot. In other instances diseased potatoes are interbedded in dunghills, or dug into the ground. In all such cases the best means have been taken for successfully propagating the disease. From all such positions many millions of conidia of the potato fungus are dispersed each June, whose special mission is to devastate potato crops. The warmth or moisture of the 'pies' [or pits] and manure-heaps are the exact conditions required by resting-spores for their maturation.

"As darkness, heat, and humidity are highly favourable to the growth of the *Peronospora*, all potatoes should be stored in perfectly dry, airy places, in positions where light is not entirely excluded. Potatoes should never on any account be stored in heaps in the damp holes in the ground termed 'pies.'"[1]

It is the general plan to store potatoes in long narrow clamps or pits, sunk perhaps 8 or 10 inches in the soil, and covered with earth and other material. It would no doubt be an additional precaution against the disease to store in a specially dry, airy position (as in the "boxing" system, see p. 274), such potatoes as are to be used as seed.

Mr Jensen has described and recommended a system of disinfecting potato-sets by heating them in a sort of oven up to a temperature of 104° Fahr. The scheme, however, is scarcely practicable.

OTHER POTATO DISEASES.

Potatoes are also sometimes attacked and injured by other fungi, notably the *Fusisporium solani*, Mart., and the *Peziza postuma*, Berk. and Wils. The former often does serious damage to the crop in the southern and midland counties of England, but has not invaded Wales or Scotland. The latter has incurred heavy losses, chiefly in Ireland, by destroying the leaves before the crop has matured.

The best method of prevention against these fungoid attacks is to burn or bury deeply all potato refuse, dead stems, leaves, and rotting tubers.

Smut in potatoes (producing a form of scab) is caused by the fungus *Tubercinia scabies*, B. It grows beneath the skin of the tuber, forming there a thin dark stratum, and showing itself by discoloured blotches on the skin. Tubers showing traces of smut should not be used as seed.

Other forms of scab may be due to

[1] *Dis. of Field and Garden Crops*, 314, 315.

some irritating influence in the soil, which, when detected, should be avoided.

TURNIPS.

"Finger-and-Toe" or Sporting.

This is a condition of the turnip plant characterised by a non-development of bulb, and a division of the tap-root into more than one branch. Sometimes the divisions resemble human fingers or toes, and hence the name.

Cause.—Professor Buckland has demonstrated that the disease is due to "a degeneration of the plant from cultivation to wildness," to which there is always a tendency in root crops exposed to adverse conditions,—such as poor exhausted soil; continuous bad cultivation; rearing of the seed without transplanting, from small or late-sown bulbs; or in a dull, dark, warm climate.

Sporting.—One form of the disease is called *sporting*. In this case the stem gets tall, strong, and branched; and the roots, mere strongly divided fangs or forks, taking such a hold of the soil as to render the plant difficult to pull up. This *sporting* is frequently seen in the south and west of Ireland, where the common turnip often runs to shaw, and even swedes frequently produce sports, which do not happen with the same seed sown in a different climate.

Remedies.—The indicated remedies are, to raise the seed from fair-sized transplanted bulbs, and good cultivation both before and after the seed is sown.

Finger-and-toe distinct from Anbury.—The name of this disease is often popularly applied to anbury or club-root, a totally different ailment having no character in common with finger-and-toe or sporting.

Anbury or Club-root.

Features and Symptoms.—This disease is characterised by warts or excrescences on the bulbs, or tap-root, as shown in fig. 399. When attacked at an early stage, club-like swellings may be seen on the minute roots before the plant is three weeks old. At other times the crop is in a more advanced stage before the disease is manifest.

The first outward symptoms of the disease often appear in a shrivelling of the leaves on a few plants, first noticed in a dry warm day. When pulled up, the tap-root is found to be more or less diseased, and the smaller rootlets may have altogether disappeared, and the bulb will be more or less affected. The excrescences rapidly increase in size, are irregular in form, sometimes like races of ginger. In

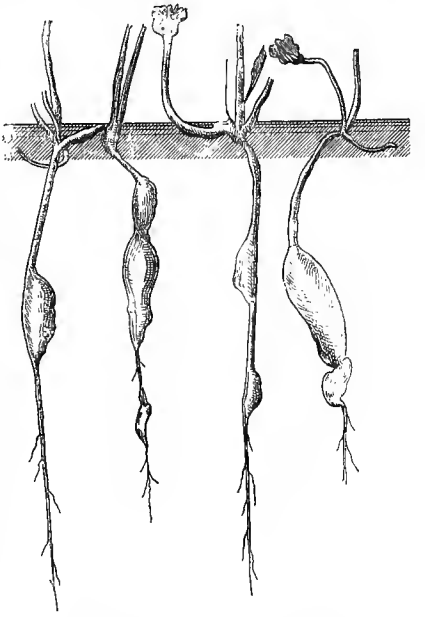


Fig. 399.—*Anbury or club-root—early stage.*

bad cases the roots decay, and, being unfit to absorb moisture or nutriment, the plant fades and dies altogether. Or the diseased roots may get amputated, and the plant throw out new roots, and recover so far as to form a fair-sized bulb.

If there is even a little of this disease in a crop, its keeping qualities will be impaired. A slight frost will cause many of the bulbs to decay; and the feeding qualities will be much deteriorated, the roots being spongy and sapless.

Cause.—The real cause of this disease has long been a puzzle. By the late Rev. James Duncan[1] it was erroneously ascribed to the attacks of the maggot of the *Anthomyia brassicæ*, the cabbage-fly, whose bite he believed produced the excres-

[1] *Trans. High. and Agric. Soc.*

cences, as that of the gall-insect produces galls.

Mr Barclay, M.P. for Forfarshire, in a prize essay written in 1863, says: "I have come to the conclusion that the 'finger-and-toe' [anbury] disease is caused by a superfluity of the combustible as compared with the incombustible elements assimilated by the plant—that is, the diseased plant has abstracted from the soil, and more particularly from the atmosphere, a quantity of combustible constituents too large in proportion to the incombustible elements which it has taken up from the soil, its only source of mineral food. This superfluous quantity of combustible elements has to be disposed of, and hence result those excres cences and abnormal growths which de stroy the plant. In short, the disease is the result of the inability of the roots to extract from the soil, as fast as the growth of the plant demands, that certain quantity of minerals indispensable for the production of healthy turnip fibre."

M. Woronin's Discoveries.—In 1878 M. Woronin, a Russian fungologist, published a paper on the club-root in cabbage,[1] which throws new light upon the allied disease in the turnip. From a translation of that paper the following extracts are taken:—

"The hernia disease attacks all varieties of cabbage, . . . turnip, rape, and so forth. In England cabbage hernia is called clubbing, club-root, anbury, or also finger-and-toes. . . . The real cause of this cabbage hernia has thus remained hitherto unknown, and now I have succeeded in finding it out. On examining the protuberances of the roots, I discovered a new organism, which I have termed *Plasmodiophora brassicæ*. . . . If we make two cross sections, the one of a quite healthy cabbage root, and the other of a root of the same age, but which already has been attacked by hernia, and compare these two sections together, we shall see that the difference between them consists solely in this—that in the diseased root some cells of the bark parenchym are filled with an opaque, colourless, fine-grained, plasmatic substance, and moreover, that the cells are mostly, in comparison with the neighbouring cells, somewhat enlarged. . . . In sections of cabbage roots that are more severely attacked, other cells are densely filled with very minute, likewise colourless globular bodies. . . . This fine-grained plasma is the plasmodium, and the small round bodies are the spores of that organism, to which I give the name of *Plasmodiophora brassicæ*.

"In all parenchym cells, which contain the plasmodium of the *Plasmodiophora*, the formation of spores gradually comes into play, and almost simultaneously the whole mass of the hernia protuberances begins to putrefy. . . . When they remain long in moist ground, the hernia protuberances soon become quite rotten, and by this means the spores find their way, first into the earth, and then into the young roots of the still quite healthy cabbages, which in their turn get quite infected with the disease. The farther development of the spore lying loose in the earth consists in the escape of a myxamœba from every spore. . . . The myxamœba do not remain long in the ground; they contrive to penetrate the healthy young cabbage roots. Unfortunately I have altogether failed to see this process of penetration actually going on under the microscope; I nevertheless assume it as an indisputable fact that the myxamœba do penetrate into the cabbage roots, right through the hairs and epiblem cells."

Mr A. S. Wilson's Experiments.—The discovery of M. Woronin has been verified by Mr A. Stephen Wilson of North Kinmundy, Aberdeenshire, who satisfied himself[2] that the fungus in the turnip club is the same fungus as M. Woronin found in the cabbage. He found turnip seeds sown in "water mixed with the pulverised clubs of the previous year to have their roots attacked." He also mixed a quantity of rotten clubs of crop 1878, containing these spores, with garden mould in which no disease existed, "and all the resulting plants became at an early stage excessively and fatally clubbed."

There thus seems a strong probability

[1] *Jahrbucher für wisscnschaftliche Botanik.* Pringsheim, 1878.

[2] Papers read to Cryptogamic Society of Scotland in 1879 and 1880.

that this fungus is the cause of clubbing, and that its spores exist both in diseased roots and in the soil, and attack healthy cruciferous plants.

Contributing Influences. — While M. Woronin has probably discovered the true cause of the disease, its virulence is greatly controlled by surrounding conditions, which affect the constitution of the crop, and alter its powers of withstanding attacks. Wet districts and soils containing much humus are more subject to the disease than soils in a dry climate, which accumulate less organic matter. The frequent repetition of the turnip crop upon the same soil, as in the four or five course rotation, is notorious as causing an aggravation of the disease, while the disease seldom causes much loss under a six or seven years' course. Working the land wet, either in autumn or spring, distinctly increases it, and ought to be avoided as much as possible. The treading of horses upon wet soil is most injurious to succeeding crops.

Manure and Anbury.—Farmyard manure, made from cattle consuming diseased turnips, and turnip-shed refuse, will infect sound land and cause the disease.

Professor Jamieson found that soluble phosphatic manures always increased the number of diseased bulbs, and, after many careful trials, he holds the opinion that sulphur in any form aggravates the disease. Dung that has lain some time in water, and urine applied with a water-cart direct to the drills, have been known to produce it.

Varieties of Turnips and the Disease.—The seed seems to influence the disease; but whether the spores can attach themselves in any way, or whether some seeds produce more vigorous plants than other seeds, and thus escape the attacks of this fungus, is unsettled. Many instances are on record where the plants from one kind of seed succumbed to the disease, while those from another variety escaped uninjured. When disease exists in a field sown with several varieties of turnip seed, it is always more virulent in some of the kinds than in others.

Its virulence may be further influenced by the weather during the working of the land, sowing, hoeing, or at a particular stage of growth.

Preventive Measures.—There seems to be no cure for the disease. The following measures of prevention, however, have been found useful: To have as many years between turnip crops as convenient; avoid taking infected dung to the farm, or, if made on the farm, use it for some other crop than turnips; secure seeds from healthy plants; avoid working land when wet; drain wet land. If a field is infected—that is, has shown the disease in the previous crop—exposing the drills to dry weather before the dung is put on has a beneficial influence. If a field get infected, the substitution of potatoes or other crop for turnips will sometimes eradicate the disease. Lime or marl, applied some years before the crop is sown, is found to have a favourable effect in lessening the disease, but when not required to benefit crops it is a rather costly remedy. A dressing of gas-lime and salt, mixed a month or two before application, has been tried with good results.

Mildew.

Turnips, like most other plants, are occasionally attacked with mildew, or mealdew, a species of *oidium*.

It is usually most injurious in dry seasons, but even very dry weather does not always lead to attacks of mildew. In some seasons the atmosphere seems to be in a state highly favourable to the development of the *oidium*.

In Scotland, in 1852, most of the turnip fields assumed a white appearance in September, the leaves rotted off, the bulbs, in most cases a fair size, ceased to grow, and after a time put out new leaves. In that season the growth of turnips was rapid and the weather dry, hazy, and dull. In 1865 turnips in many parts were badly mildewed in August, during a period of dry, hazy weather. Wherever a plant had much extra space, it was not affected, but kept green the whole season.

There does not seem to be any practical method of checking the *oidium*, once it has fairly set in, as the crop is not usually of sufficient value to admit of the application of sulphur, which is so effective in the vine disease. Fortunately the disease is only now and then injurious.

HOPS.

Mildew. — The hop mildew, *Spœrotheca castagnei*, is the most destructive of several kinds of fungi which attack hop plants. It is commonly known as "mould," and is in many respects similar to the much-dreaded potato fungus, the *Peronospora infestans*. The mould first appears as whitish, mouldy blotches on the leaves, soon becoming discoloured and developing the black receptacles on the surfaces of the leaf. These mouldy patches appear on the plants where they have formed burrs or cones, and soon after they will blacken and decay.

As means of prevention, Mr Whitehead says that it is most important to destroy every particle of bine by burning, and to remove all rubbish and refuse from the proximity of the hop grounds.

Sulphur is the most effectual remedy known for mould. Finely powdered sulphur is blown on to the plants by means of a machine called a hop-sulphurator, drawn by a horse between the rows of hops. A fan revolves quickly in a trough containing the powdered sulphur, throwing it up in clouds all over the plants. From 50 to 80 lb. of sulphur are applied per acre at one operation. It is found that the best time to sulphur hops is on a calm, sunshiny day. Sulphuring hops is now a regular process upon many farms whether mould appears or not, and then if the mould should happen to appear, the sulphuring is repeated. Experienced hands must be employed in sulphuring or syringing hops.

Another fungus which attacks the hop plant is an imperfect fungus belonging to the group of parasitic fungi known as *Uredineæ*. Sulphuring is equally effective in combating this enemy.

LIVE STOCK IN SUMMER.

During the months of summer the farmer bestows a large share of his attention upon live stock. Animals on pasture usually give comparatively little trouble, yet it is desirable that they should be carefully observed and promptly attended to in any matter affecting their health and progress.

It is the rule in this country for all kinds of farm live stock, excepting horses in daily employment, to find their subsistence on the arable pasture fields and natural grazing lands. In many instances, however, cattle, such as dairy cows and fattening cattle, are housed and fed under cover in summer as well as in winter. This latter method of summer management will be noticed later on. We will first deal with the animals on the pastures.

PREPARING PASTURE FOR STOCK.

Before giving the stock possession of the pasture fields, it is advisable to attend to some preliminaries, such as stone-gathering, rolling; and in particular to inspect the state of the fences, in order to put them into such repair as to prevent the stock scrambling through gaps, to the injury of the fence and themselves.

Removing Surface Stones. — On every kind of soil, any stones inconveniently large which are lying upon pasture should be gathered by the field-workers, and carted away for use on the farm-roads. It may happen that the pressure of other field-work may prevent horses and carts being given for this purpose. In that case the stones should be gathered in small heaps upon the furrow-brow of every other single ridge.

But it should be remembered that heaps of stones occupy much ground, and prevent the growth of as much grass; so that they should be carted away as soon as possible. When carts are used, the stones are thrown directly into them whereas heaps require to be carefully piled up, which wastes time, and they have to be removed after all. Some farmers are regardless of gathering stones from pasture fields, while all acknowledge that stones ought to be cleared from grass intended to be cut for hay. In wet

weather no cart should be allowed to go upon, or stones be gathered from, new grass on any soil.

Rolling Grass Land.—Every field of grass that is new, or that is loose and spongy on the surface, should be rolled with the smooth roller some time before the stock enter upon it; and unless the ground be cleared of stones, it cannot receive the full benefits of rolling. The best time for rolling is when the surface is *dry*, and not *hard;* for when young grass is rolled with the land in a hard state, it is bruised and blackened; and when the grass is wet, it is too much pressed and flattened; and when simply dry, its elasticity causes it to spring up after the pressure of the roller. Light land bears rolling at any time when the surface is dry, the clods being easily crumbled down; but grass is bruised between the roller and hard clods on clay land, and rolling causes soft clay to become encrusted on drying. Rolling clay land thus requires consideration; and the only criterion of its being in a fit state for the roller, is when clods crumble down with pressure of the foot, not merely become flat on account of their toughness, or enter whole into the soil. Rolling is done across the ridges. After rolling, grass grows rapidly if the weather be favourable; but if frosty, it assumes a brown tint.

Repairing Fences.

While the surface of the field is thus being prepared for stock, the fences should be repaired.

Hedges.—The hedger repairs the thorn fences. In this he is often assisted by the shepherd; and where there is no hedger, the shepherd or cattle-man undertakes the duty. The repairing of hedges consists in filling up gaps. Gaps occur in hedges by death of plants, or by trespassers. Gaps are made fencible by drawing a strong thorn branch across the hedge *roots*, or by driving 2 stakes in the face of the hedge-bank behind the gap, and nailing 2 or 3 short rails on them, or 1 or 2 pieces of plain or barbed wire, or by wattling the stakes with branches of trees or thorn, or by setting a dead hedge upon the hedge-bank.

Nothing should be placed *in* the gap, as it prevents the lateral shoots of the thorn plants filling it up. A wide gap should be filled up at once with living plants, or with young stems from the hedge on both sides.

Stone Fences.—Stone fences should be repaired by a dry-stone mason, by replacing copestones, or rebuilding part of the wall where it has crumbled down. It is seldom that the stones driven or fallen down can repair a wall, so that fresh ones have to be provided. The stones left on making repairs should be immediately removed. In making repairs in all sorts of fences, a means should be provided for allowing the cattle-man or shepherd to go from field to field when looking after his flock. This may be in the form of a passage through the fence, or of steps leading over the top of it.

Repairing Gates.

Besides the fences, the gates of grass fields require inspection and repairs. A broken post or bar should be replaced by the carpenter, and the iron-work repaired by the smith. The most convenient position for a gate, for easy entrance into and egress from a field, is at the end of one or both head-ridges. Field-gates should fold back upon the fence, and should not shut of themselves. When they shut of themselves, they are apt to catch the wheel of the passing cart, and be broken, or the post snapped asunder. People pass through self-shutting gates without fastening them, and young horses take delight to loiter about gates, and escape through such.

Young horses rub against gates; a thorn or whin-branch, wattled through the bars, prevents them. So does barbed wire, but it is liable to inflict serious injury on both man and beast in exposed situations.

Fixing Gate-post.—We have found a good plan of fixing a hanging post for a gate to dig a narrow hole, 3 feet deep, and lay a flat stone of about 15 inches square, and 7 or 8 inches thick on the bottom, at the centre of which is cut a hollow 8 or 9 inches in diameter, and 3 or 4 inches deep, to take in the lower end of the post, dressed with the axe to fit the hollow. On setting in the post perpendicularly, earth alone is put in spadefuls in the hole around the post,

and rammed hard up to the surface of the ground. Fig. 400 shows the hole into which the post is sunk, as also at the bottom the stone in which the end of the post is inserted. The lower end of the post has the bark on and smeared with coal-tar, and the upper part is planed and painted. Earth, hard rammed,

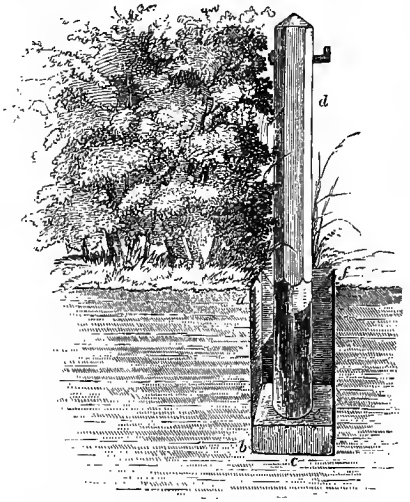


Fig. 400.—*Secure mode of fixing the hanging-post of a field-gate.*

a b Hole for the post.
c Stone at the bottom of the hole.
e Insertion of the post in the stone.
f Stone for heel-post of gate.
d Crook for gate.

holds a wooden gate-post more permanently firm than the small stones commonly used, however compactly jammed in round it. Part of the hedge-fence of the field is also shown, and the crook on which the gate is hung.

Water on Pastures.

The importance of having pasture fields well supplied with fresh, pure water for stock can hardly be overestimated. This has more to do with the progress of grazing stock than is generally imagined. It is indeed one of the conditions which are absolutely essential to the profitable grazing of stock.

Assuredly in every field in which horses, cattle, or sheep are grazed day and night, or even for a whole day, there should be a supply of water.

Quantity of Water for Stock.—The quantity of water which the different classes of farm animals require for their daily wants on pasture varies greatly, according to such influences as the succulence of the pasture, the heat of the sun, and the amount of exercise. It has been estimated that on pastures in dry weather horses and cattle require about five gallons of water each per day, and sheep about half a gallon. The aim of the owner should be to let the animals have access to pure water when they feel in want of it, and there will be little danger of the animals drinking more than is good for them. That is, if they have had no undue exercise or other stimulus to excessive drinking.

Running Water.—Running water is the best of all, for with ordinary care it is most likely to be pure and fresh. If there is no open stream which can be diverted into the field, it may be possible to draw in a supply by a pipe from some adjacent stream.

Pump Water.—Failing this, a pump may be sunk and worked either by hand or windmill. When a trough is employed to hold the field supply of water, the trough should be thoroughly cleaned out at least every week. This will cause little trouble if the trough is made with a plug in the bottom, so that it may be washed out.

Rain-water Ponds.—If this, again, should not be practicable or sufficient, then means may be employed for collecting and preserving for drinking purposes the water of the rainfall. For this purpose ponds are formed. These ponds are generally circular in shape, 4 or 5 feet deep in the centre, rising towards the edges, and from 30 to 60 feet in diameter, according to the number of stock to be supplied. The bottom of the pond is lined with about a foot of moist clay, trodden firm, and it is a good plan to prevent damage from worms to lay on the top of this a layer of quicklime, fully an inch thick, and then follow with another layer of clay, perhaps not quite so thick as the first layer, but pounded tolerably firm. This should form a pond which will be sufficiently water-tight. In some cases ponds are made with one layer of clay and mixed with lime to prevent the depredations of worms, with a layer of straw on the top to prevent the sun from cracking the

clay, and then over all a coating of small stones.

Reliability of Ponds.—It is really surprising how faithfully ponds so made retain a supply of water. It is perhaps still more surprising how, in some circumstances, they collect the water which they constantly contain. High up on the downs in the southern counties of England there are artificial ponds which are so situated that they cannot possibly be fed from springs in the soil, and which have nevertheless for many years maintained a constant supply of drinking water for the flocks that feed around them. The old idea that the supply was kept up by the condensation of dew upon the cool surface of the water (hence the name *dew ponds*) has been shown to be erroneous. The source of supply is unquestionably rainfall, and this is so abundant in all parts of the United Kingdom, that if proper ponds were formed for the conservation of rain-water, there is no farm or field in the country which could not thereby be well supplied with drinking water for animals.

Care of Ponds.—When these ponds have to be depended upon for drinking water for animals, the farmer must take care to see that they are kept clean and in good order. As a rule, it will be sufficient to have the pond cleaned out once a year for a couple of yards or so round the edges where the animals may leave droppings. The pond should be carefully examined now and again, to ensure that its water may not be contaminated by any animal matter decaying in it. It is by no means rare to see the body of a dog or cat decaying in drinking-ponds. Can it be healthful for animals to drink water so tainted? It must indeed be positively injurious to their health.

These ponds should be placed at corners where each pond might supply two, three, or more fields, and where they would also be out of the way of tillage operations.

Carting Water.—Carting water to pasture fields is a serious affair, yet in many cases it has to be done daily during the entire grazing season.

Rubbing-post.

Every pasture field should be provided with two or three good rubbing-posts. These should stand about 6 feet in height. The surface should neither be so rough as to injure the skins of the animals, nor so smooth as not to afford a satisfactory scratching. Perhaps the best material for a rubbing-post is the trunk of a spruce-tree, with the branches sawn off, not too close to the trunk.

Salt on Pastures.

A little salt is relished by stock on pastures and is beneficial to them, especially in the case of cattle and sheep. A convenient way of giving this is in the form of lumps of rock-salt placed here and there over the pastures, either upon a close piece of grass or in a shallow wooden box.

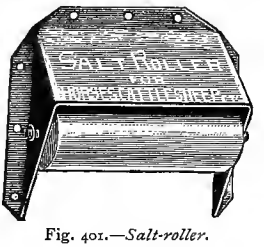


Fig. 401.—*Salt-roller.*

A very useful contrivance for holding rock-salt within reach of stock, and yet preserving it from becoming filthy by rolling on the ground is shown in fig. 401 (Spratt's patent). It is attached to a post at a height to suit the class of stock in the field.

Weeds on Pastures.

Sufficient attention is not given to clearing weeds off pastures. Upon arable farms all obnoxious weeds in the pasture fields should be most carefully cut down or pulled up by the root, according to the nature of the weed. As a rule, one timely cutting will suffice. This should take place early in the grazing season, so that the weeds may not be allowed to run to seed. With some weeds, such as thistles, a second cutting later in the season may be necessary.

There is usually a plethora of weeds by the sides of roadways, hedges, and other divisions, and these should also be ruthlessly cut down.

Permanent pastures should likewise have attention in this matter; while on pastoral farms there may be green patches on the lower parts which would repay the trouble of clearing them of weeds. "Weeds," wherever they appear, are

enemies to the farmer, and should have no harbour.

SHEEP IN SUMMER.

The important question as to what sheep should be disposed of for slaughter and what retained for grazing when the supply of turnips has been exhausted, will depend upon circumstances which are liable to almost infinite variation; such, for instance, as the price of mutton at the time, and the prospects of a rise or fall in the near future, the condition of the sheep—whether well prepared for killing or not; the class of sheep—whether of a kind likely to be in demand later in the season, or to be useful and required for breeding on the farm; as also the general plan of management on the farm, and the probable supply of pasture. All these and other circumstances tending to regulate the actions of the flock-owner are subject to so many variations that each farmer must be left to decide for himself at the time. Only this general advice will be ventured upon —it is prudent to sell fat stock when prices are fairly satisfactory; better a fair price in hand than the prospect of a big price in the uncertain future!

Pasturing Sheep on Arable Farms.

The method of pasturing sheep on arable land will be regulated according to the class of stock kept and the nature and management of the farm. The stock may be a breeding or flying (hogging) one, or a certain modification of either, or both these recognised classes. A ewe stock is generally found where the farm is largely under rotation grasses or permanent pasture. The hogging system, on the other hand, prevails where the farm is worked in rotation, and the soil adapted for turnip culture.

Ewes and Lambs.—In the spring division of this work we left the ewes and lambs on the new grass. To lighten the demand on the young grass the earlier lambed ewes with their lambs may be drafted away to the more distant and perhaps less sheltered fields of older grass. Gradually they may be followed by the single lambs and the stronger doubles, thus leaving only the weaker doubles or any weakly single lambs (with their mothers of course) on the new grass.

This gradual transference not only prolongs the supply of young grass to the animals most in need of it, but also allows time for the permanent pasture to obtain a satisfactory start. After this, in average seasons, there will likely be little difficulty as to food. Let the new grass be moderately cropped, but not too closely eaten. See p. 78, Divisional vol. iii.

Scarcity of Grass.—It may often happen that in a backward season the grass, old and new, but especially the old, comes up so slowly as to make it difficult for farmers to carry their flocks successfully through the earlier weeks of the grazing period. In this event it will probably be the better plan to keep the ewes (with their lambs) for a time on artificial feeding with a run on the new grass, turning them out to the old pasture in the evening Linseed-cake and bran mixed—½ to ¾ lb. each daily, according to the supply of grass—will be found good food for ewes in milk.

On hogging farms the difficulty is more easily overcome, but with them also it of course involves additional outlay. Until the grass has become plentiful the hoggs or non-breeding sheep may be kept on winter fare, minus the turnips, which may have been exhausted long ago. Upon cake, bran, bruised oats, and chaffed hay, with access to water and rock-salt, these sheep will thrive admirably.

Attention to Ewes and Lambs.—The duties of the shepherd, after he has placed his flock on the pasture, are comparatively light. Still there are a few matters which require attention from him. He must carefully observe the ewes, to see that the lambs are sucking properly. Many ewes, owing usually to sore teats, refuse to allow their lambs to continue sucking; and, if neglected, garget or udder-clap may set in. The ewe must be held till sucked, and the teats anointed with some healing lotion.

If a lamb does not seem to care for its mother, it will generally be found that the ewe has little or no milk. In this case the lamb, now likely able to forage for itself, should be put on some extra food, and the ewe turned out to the poorest pasture on the farm.

Summer Treatment and Disposal.—The kind of treatment as to food which the various classes of sheep will receive during the summer will be regulated to suit the end for which they are intended—when and for what purpose they are to be disposed of. Sheep intended to be fattened and sold for slaughter during the summer and autumn, or early in winter, will of course be treated differently from those to be carried on in store condition.

Summer Fattening.—Sheep intended to be fattened on the pastures during summer are usually graded in lots, according to the conveniences on the farm in the way of separate fields. And it is a matter of great importance on grazing farms to have a good many fields of small or moderate size, rather than fewer fields of greater area. Of the sheep to be fattened a draw of the best is made, and these are put into the best piece of pasture. With plenty of good sweet pasture, and perhaps a little cake and grain, they will now fatten rapidly. Bruised oats are much in favour for fattening sheep on pasture.

The remainder of the sheep for fattening may be still further graded or kept together as will best suit the arrangements of the farm and the objects in view. It is usually advantageous to have the fattening sheep coming into a fit state for slaughter at different times instead of all at once. In this way they can be sold in small lots, as the condition of the market may dictate. The plan of grading in the feeding is therefore a good one, and should be carried out as far as possible.

When the first lot has been disposed of, the second is taken in hand and similarly pushed on till ready for the market; and so on till the entire stock of feeding sheep has been disposed of.

Store Sheep in Summer.—The sheep to be kept simply in good store condition during summer are of course treated less sumptuously than the fattening sheep. A common plan with a flock of hoggs is to select the leanest and smallest, and assign these to the best of the pasture available for the store sheep, so that upon this (and perhaps a little extra food in the shape of oats) they may so develop as to "match" more evenly with the "tops" at the time of selling.

The wether hoggs will most probably be disposed of after clipping, and then the ewe hoggs, which may hitherto have had the poorest of the pasture, can be promoted to better grazing.

Shifting Sheep on Pastures.—When sheep are enclosed on fields, it is very desirable that they should be frequently shifted on to fresh pasture. The change will be beneficial both for the sheep and the pasture. It will be all the better for the sheep if the changes can be arranged from poorer to richer food. Where the fields are large they should be divided, perhaps by a temporary fence of wire or iron hurdles—iron hurdles on wheels being specially suitable for this purpose, although rather expensive. Certain fields, or portions of fields, should be allowed to grow up well for a short time, and when the sheep are removed to these preserved portions, the pastures they have left will make headway, and afford another fresh change when it becomes desirable.

Animals are fond of changes in this way; and by being thus cropped and allowed to grow alternately, pastures produce more food than if cropped continuously throughout the season. Many flock-owners change the stock from field to field every three weeks, taking care never to allow the grass on any one field either to grow too rank or be too closely eaten.

Water for Sheep.—There is a prevailing idea amongst many farmers that there is little or no necessity to provide water for sheep on pasture. This is a serious mistake, which is responsible for greater losses to flock-owners than would be readily imagined.

Much of course depends upon the pasture and the weather. On succulent pasture with heavy dews sheep may require no further supply of water; but in dry weather and on dry pasture they cannot thrive and maintain good health without access to water.

For ewes and lambs in particular water should invariably be provided. It is especially necessary if artificial food is given. For sheep as well as other animals running water is best; and if it is supplied in ponds, see that these are kept clean. Many diseases are traceable to

the drinking of impure water. It is a fertile source of blood-poisoning and dysentery.

Salt for Sheep.—This is especially necessary for sheep. It gives tone to the system, and should always be within their reach. Common salt may be given to them in partially covered boxes on the fields, or rock-salt may be put within their reach.

Maggot-fly.—During warm weather, the shepherd should have his eye upon every sheep on the farm at least twice a-day. At this time they are liable to be attacked by the "maggot-fly." If any animal is seen to be restless, twisting its body, shaking its tail, and running forwards with its head bent down, the shepherd should catch it, and most likely on close examination he will find a colony of maggots located about the hind parts. In hot weather the shepherd should never go to the fields without having in his pocket a bottle of dip-mixture or fly-oil. With this he anoints the part attacked, and shakes out the maggots from the wool. This simple treatment will be quite sufficient.

After lambs have been weaned, and the summer dipping having taken place, there will be little further trouble from this pest.

Unclipped Sheep Falling.—Long-woolled sheep, hoggs especially, before being clipped, are so loaded with wool that, when annoyed by the ked, they are apt to roll upon their backs; and when that happens in the hollow of a furrow, they cannot get up again. They then lie *awkward* or *awald*. Should they lie for some time with their head down the hill, with the stomach full of food, they may die of apoplexy. A careful shepherd will not allow any sheep to die thus. He cannot prevent them falling awkward, but as long as sheep are rough, he should visit them frequently. Sheep are not easily discovered lying awkward in a furrow, so he should cross the ridges and view the furrows in length. An accustomed eye can detect the hind-hoofs in the air at a considerable distance.

Many collie dogs are quick in observing sheep in this state, and some will run and take hold of the wool near the ground, and pull the sheep over on its feet. Shepherds cannot be too alert in visiting sheep on pasture at this season.

Ravens Injuring Lambs.—Lambs are subject to serious and even fatal injury on farms situate on the rocky cliffs of the ocean, from the raven, *Corvus corax*. This formidable bird comes upon lambs asleep, pecks a hole in the abdomen, and draws out the entrails. Should the lambs be awake, it dabs out their eyes. Even hoggs, when fallen awkward, have had their eyes picked and their entrails pulled out by these birds.

Pasturing Sheep on Hill-farms.

We will now describe briefly the system of management pursued on hill-farms in carrying on the flocks from spring until weaning-time.

Stocking on Hill-farms.—The classes of sheep kept on hill-farms are arranged to suit the character of the land, the nature of the pasture, the altitude and exposure of the farm. A common plan is to maintain a stock of ewes on the low ground attached to hill-farms, or where the heath is well mixed with green ground, or interspersed by streamlets with green banks. Young sheep are placed on ground similar in character, but with a less admixture of green pasture. Older sheep and wethers generally occupy the higher grounds, where the exposure and cold would be too great for ewes and lambs and young sheep.

Ewes and Lambs.—The handling of a typical hill-flock of breeding sheep in the lambing season is described on page 73, Divisional vol. iii. We have seen that the large "hirsel" there, 500 head in charge of two shepherds, has passed through the lambing ordeal, and been turned on to the usual run of pasture. There is less work here in the changing of pastures than on arable farms with small enclosures. The shepherd, however, must be daily amongst the flock, and see that, by now and again moving them from one part of the ground to another, the ewes and their produce are kept in good thriving condition.

The ewes and lambs are turned on the higher and blacker ground for a change towards evening, and admitted again for a run of the green pasture during the earlier part of the day. A careful and intelligent shepherd soon learns when to

give his flock a turn from one part of the ground to another.

Pasture Plants on Hilly Ground.—The intelligent shepherd observes carefully the different kinds and succession of pasture plants suitable for the feeding of sheep, and as these attain sufficient growth he gives his flock a turn upon them. For instance, in most parts during January and February, "mossing" is usually plentiful; in April and May, "deerhair" becomes a standard plant; in June, July, and August, green banks, "haughs," and old pasture land are at their best; in September and October, "prie" and "stool bent" come up; and in November and December, "moss leek" and coarse bent and heath come in for use.

There is thus upon hill-farms, embracing high and low ground, a wonderfully complete succession of pasture plants. It is the object of the careful shepherd to take advantage of these as they come up in turn; and the flock-owner's balance-sheet may be largely influenced by the manner in which these successional growths are observed and utilised.

Heather-burning.

As heath constitutes a large ingredient in the food of mountain sheep, it is important that heath-burning should be carried out systematically, so as to have at all times a succession of young and old heath. Sheep-farmers have long been in the habit of burning a portion of the heath on their farms every year, with the view of allowing it to grow again, that its young shoots may support sheep in those parts of the grazing where there is little grass. Burning causes an abundant growth of young shoots; it is therefore the interest of both landlord and tenant that the heath should be so burned as to produce the greatest growth of young shoots.

Method in Burning.—The question of burning being thus established on principle, the difficulty at first was to discover a mode which would produce the best results. At length a good plan was discovered, and it is this: Let that part of a hill-farm which bears heath be divided into eight equal parts, because beyond that number of years the heath plant grows so rigid as not to afford many new shoots, and it has then reached 1 foot in height, which is tall enough for grouse. The first portion is burned in the first year, the second portion in the second year, and so one portion every year, until the eight years have gone round. Every year the plants which were first burned will be putting forth fewer shoots as the expiry of the eight years approaches; by which time the first portion is burned again, as the commencement of a new series of years. In winter the snow covers the youngest shoots and protects them under it, while the older plants being above the snow, both grouse and sheep feed upon them; and in spring, on the melting of the snow, the young shoots, tender and nourishing, are ready for use. It is remarkable that the young plants of heath bear the frost better than the old.

Old Method of Burning.—The old mode of burning was to set fire to the heath on the *windy* side, when the blaze soon towered to a great height, and was seen at a great distance, and the plants crackled amidst the scorching heat; but the heat which produced the crackling destroyed the plants by the roots, and the flame, fanned by the gale, ran along the ground, catching every bush that presented itself, until a much larger space of ground was set on fire than was desired. The conflagration, indeed, often became so extensive that the shepherd and all his family could not extinguish it. The flame went wherever the wind listed, till there was no more heath to consume, or until the wind lulled, or the rain fell.

Modern Method.—The burning of heather nowadays, being controlled by the regulations of the property, is done at the sight of and with the assistance of the gamekeeper and his gillie; the shepherd helping and pointing out the most suitable parts. On large hill-farms, heather-burning must be done on the ground of the separate hirsels. Where streams run through the hill ground strips of heather are burned from 120 to 200 yards in breadth, running from the bank of the stream through the hill, often a mile in distance, when suitable ground exists. Heather takes at least three years before it sprouts after burning, but often on the burned ground other plants come up soon which are useful to sheep.

SHEEP-WASHING.

There has from time to time, and more particularly in recent years, been much discussion as to the utility of washing sheep before clipping them.

Objects in Washing.—There is a two-fold object in washing sheep—to free the wool from earthy material and improve its lustre, and cleanse the skin of the sheep from incrusted matter.

Opposition to Washing.—It is maintained by many flockmasters that any depreciation in the price per pound for unwashed wool is fully compensated by the greater weight of the fleece. It is better, the opponents of washing contend, that the cleaning of the wool should be left to the manufacturer who has appliances which enable him to do the work in a more thorough and satisfactory manner than could be done on the live sheep on the farm. Then, again, it is argued that the advantage to be derived from having the skin of the sheep cleaned by washing may be more than counterbalanced by the risk and trouble arising after washing; and that after clipping the skin of the sheep will be sufficiently cleaned by the natural rainfall.

The opposition to washing has probably been gaining strength, yet the practice is still largely pursued in this country.

Study the Market.—Perhaps the best guide as to the expediency of washing sheep will be the tendency of the wool trade — whether washed or unwashed wool finds the greater favour, or brings relatively the higher price. Farmers must consider these points carefully from time to time — such matters, indeed, should be their constant study — and it will be their object to arrange their method of management to suit the spirit of the age.

Methods of Washing.—There are different methods of washing sheep. Plans often adopted are here described. A pool of about 3 feet deep of water is made across a natural rivulet having a slope on each side, and both margins clad with grass, the slope for the egress of the sheep being the easiest, so that there be no struggling to get upon the bank when the wool is loaded with water.

When a rivulet is awanting, a pool should be constructed in a large ditch having a command of water, and both banks lined with a clean sward of grass. A damming should be made across a rivulet even if it have a pool of sufficient depth of water, as the water will flow quicker and be cleaner in an artificial dam. The bottom of the river or ditch should be hard and gravelly, and the water pure, or it will not answer the purpose. A soft and muddy bottom and dirty water will soil instead of cleanse wool.

A damming is best made with an old door or two, or other boarding, supported by stobs driven in the rivulet, and the chinks at bottom and sides stopped with turf in the inside. When the water accumulates, it falls over the boarding at the centre with such a current as to carry off quickly every impurity—as earthy and greasy matter, small locks of wool, and scum. A damming in a ditch is made of the same construction, and with the same materials and depth of water.

One side of the pool is occupied by the unwashed, and the opposite by the washed sheep. They are confined in their respective places by hurdles or nets. To prevent the sheep leaping into the water of themselves, which they are apt to do when they see others in before them, the fence should be returned along the sides of the pool as far as the men who wash the sheep take up their stations. Fig. 402 shows a damming with doors and stobs, and the overflow of water in the centre. The net on each side of the pool is returned far enough on both sides. The water is at the proper depth for the men.

Everything is now ready at the pool, the sheep having been separated for the washing. The tups are washed first, then the hoggs and wethers, and lastly the ewes. Hoggs and wethers are generally shorn in May, while ewes are left unclipped until about the middle of June, the exact time being dependent on the character of the season. Cold weather after the ewes are clipped will make the milk supply very scanty, if it does not stop the supply altogether. It is thus advisable that the hoggs and wethers should be washed 2 or 3 weeks earlier than the ewes. Lambs are not

washed, and are kept apart when their mothers are being washed.

Force Required.—The men who wash cast their coats, roll up the sleeves of their shirts to the shoulders, and have old trousers and shoes in which to stand in the water. Long fishermen's boots, or india-rubber leggings, would provide good protection to the men.

The shepherd and two ploughmen are usually sufficient to wash a large number of sheep thoroughly; but should the stream be broad, a third may be required, to save time in handing the sheep from man to man. The three men in fig. 402 are the shepherd (who is the last man to handle the sheep, and is farthest up the pool) and two assistants. Two men are required to catch the sheep for the washers.

On this occasion the men receive bread and cheese and ale, and also a dram of spirits, as a safeguard against a chill while standing for hours in the water. The collie keeps watch, and is ready in case of an outbreak.

Process.—The washing is performed in this way: While the three washers are taking up their respective positions in the water, the two catchers are capturing a sheep. The catching is fatiguing work, and, to make it easier, the enclosure should be small, to contain the sheep closely. A sheep, being caught, is presented to the first washer, who, on taking it into the water, allows the wool to be saturated, then turns the sheep over on its back, holding up the head by seizing the wool of the near cheek with his left hand, and grasping the arm of the off fore-leg with the right. With this hold he dips the sheep up and down—pushes it to and from him—turning it from one side to the other slowly, and causing the wool to wave backwards and forwards, as if rubbing it against the water. These motions are easily effected, even a heavy sheep feeling light in the water. During the operation the water becomes turbid about the sheep, and he continues the agitation till the water clears itself, when he hands the sheep to the next washer in the middle and higher up the stream. Whenever he gets quit of one sheep, another should be ready by the catchers for him to receive into the water.

Fig. 402.—*Washing-pool and sheep-washing*

a a Damming with doors and stobs, the surplus water pouring down in the centre.
b Man catching an unwashed sheep for the first washer.
c First washer, who stands lowest down the pool.
d Second washer, mid-way in the pool.
e Shepherd, farthest up the pool and last washer.
f Washed sheep going out of the water.
g Washed sheep within the enclosure.
h Collie beside the provisions.

The second washer, on receiving the sheep from the first washer, holds it and treats it in the same manner, and then hands it to the shepherd a little higher up the stream, and is ready to take another sheep from the first man.

Duty of the Shepherd.—It is the

duty of the shepherd to see that the skin of the sheep is cleansed, and every impurity removed from the wool. The sheep on its back is in a favourable position for the rapid descent of earthy matter from the longer part of the wool. Wherever he feels a roughness upon the skin, whether on the back or belly, groin, breast, or round the neck, he scrubs it off with the hand. Being satisfied that the sheep is clean, he dips it over the head while turning it into its natural position, when it swims ashore, and gains the bank. On coming out of the water it walks feebly, its legs staggering under the weight of the dripping fleece; and in a little it frees itself from the remaining water by twirling the fleece like a mop.

In the echelon position in which the men stand in the water, the sheep in its dirtiest state is in the hands of the man farthest down the stream, where the impurities flow away, and come not near the other men. The sheep being in a comparatively clean state when it reaches the second man, the water cannot much dirty that which runs past the first man, and still less the water from the shepherd soils that near the other two men.

Hours for Washing.—The afternoon is generally chosen by shepherds for washing sheep, but the morning is a better time, inasmuch as the fleece will have become much drier during the day than in the night when the sheep are washed in the evening, when they must feel uncomfortable with a wet fleece.

Effect on the Sheep.—Sheep are differently affected in the time of washing. Some disregard the plunges, and seem to enjoy them, giving themselves up entirely to the will of the washers; whilst others are in a state of great terror, struggling against every new motion, and groaning in anticipation of greater danger. Some are very expert in turning their backs upwards should the washer be off his guard and dip them too perpendicularly down; and when turning themselves quickly, they are apt to injure the bare arms of the washer with the hoofs of the fore-feet.

Speed.—In this way from two to three scores of sheep may be washed in an hour, according to the size of the sheep, the activity of the washers, and the supply of water.

After Washing.—After washing, sheep should be driven along a clean route, and be put into a grass field having no bare earthy banks, against which they might rub themselves. They should be kept perfectly clean until their fleeces are taken off.

Interval before Clipping.—How long the fleece remains on after the washing depends on the state of the weather. The wool must not only be thoroughly *dry*, but the *yolk*, the natural oil of the wool, must return into it again; and further, the new wool should have risen from the skin before the old is taken off. Disregard of this particular renders clipping difficult, and certainly deteriorates the appearance of the fleece. Perhaps eight or ten days may suffice for these effects.

No apprehension need be entertained of the fleece falling off when the new growth commences, for wool will remain for years upon the sheep's back if not clipped off, and the sheep be free of disease.

Another Method.—Another method of washing sheep, often pursued on pastoral farms, is as follows: A deep pool in a river is selected, or, failing this, a damming is made in the gully of a rivulet; and where no river exists, a suitable part of a lake is selected. A small space is enclosed with hurdles near the edge of the water; a narrow passage, fit to contain two sheep and two men in breadth, is made from the hurdles to a rising-ground or rock, which projects into and is 5 or 6 feet above the water; and from this the sheep are made to leap into the water one by one. On leaping from that height, the sheep go over the head, and on swimming reach the dry land, where another enclosure of hurdles is ready to receive them. They are thus treated several times till they are clean.

Bath Washing.—Where there is no stream or suitable pool at hand, and where the flock is small, a large bath or tub may be made for the purpose. Many contrivances are in use, some very primitive, yet efficient enough, if not very speedy.

Hungarian Method.—In some parts of Germany great pains are taken with the washing of sheep. At Alcarth, in Hungary, the washing is done under roof

in the following manner: The first operation is to dissolve and loosen the dirt in the fleece. For this purpose a soaking vat has to be put up, which is covered and tightly put together of strong planks or boards. It is filled with hot water, equal to 84° Fahr.; the sheep are then placed in two lines, and constantly handled until the yolk and dirt are dissolved, which ordinarily takes from fifteen to twenty minutes. The solvent effect of the water is increased by adding a few pounds of *potash*, and also by the *lye* arising from the natural oily matter of the wool. The sheep, after being well soaked, are placed under shelter, where they have to wait their turn of the shower-bath, in order that the animal, now too much heated, may not pass immediately from the hot *soaking-vat* into the *shower-bath*, this being from 61° to 63° Fahr. The water is let upon the sheep through a hose with a strainer at the end. It falls with considerable velocity, and is brought to bear upon all parts of the sheep until the wool is of a snowy whiteness. The sheep are then driven to a warm dry shed, and shorn as soon as the wool is dry, generally about the sixth day. On an average forty sheep are thus washed in an hour.

Australian Methods.—To suit the enormous flocks in the Australian colonies, elaborate washing appliances have to be provided. There, from £1000 to £2000 has been spent by some sheep-farmers for steam-engine and washing-gear. In Scott's *Practice of Sheep-Farming* there is the following description of the very complete arrangements for sheep-washing on an Australian farm (Mount Fyans): "The plan adopted is to pass the sheep through a cold-water tank over night, which washes a good deal of the loose dirt off the bellies and legs, and thoroughly saturates the fleece. They are then packed pretty closely in a sweating-house, with numerous subdivisions in it to prevent the sheep from being smothered. By this means the points of the wool are softened, and the work of cleansing the fleece is rendered very much easier than it would be if the sheep were taken into the wash without this preparation. The hot-water tank into which the sheep are put next morning has three divisions, in each of which they are well crutched. At the end of this tank there is a movable floor, which is raised by a lever, so that the sheep leave the tank without having to struggle up a steep incline. The water is heated to about 108° or 116° Fahr., and bar soap is used to soften it, and render the process of cleansing the wool more easy. After draining for a short time, they are passed down shoots to the men at the spouts, where, on Sharp's patent sheep rollers, they are well spouted; and when the hot water has been fairly driven out of the wool, they go on to the landing-stage, where they drain for a time, and are then allowed to walk on the grass by a long battened stage. The water for the wash is drawn from a large dam, which is kept constantly full by a stream from the spring in front of the house. Centrifugal pumps are used to throw up the water to a height of 12 feet, and one spout will wash about 500 sheep a-day."[1]

Lambs.—The lambs are restored to the ewes immediately after the washing. Some advocate washing lambs as well as the older sheep, but this is not advisable. When still on milk they are susceptible of changes, and a chill then arising from a wet state of their body might engender serious disturbance throughout their system. No possible good can accrue to them from washing.

SHEARING OF SHEEP.

This is an interesting event on sheep-farms. In most parts the sheep-shearing is regarded as a joyous occasion—a sort of harvest—in which a liberal allowance of beef and broth and ale is dispensed to the clippers engaged in the laborious work. It is a point of great importance to have dry settled weather for this operation; and as the time approaches, flock-owners watch the weather indications with some anxiety.

Time of Shearing.—The exact time of shearing varies with the locality, the class of sheep, and the season. The clipping season may be said to extend from the middle of May till the end of July. The new growth of wool should

[1] *Prac. of Sheep-Farming*, 134.

be well started before the clipping begins.

If the sheep have been washed, they may be clipped about eight or ten days thereafter.

The tups are first shorn, then the hoggs and wethers, and lastly the ewes.

Clipping-place.—On Lowland and mixed husbandry farms a covered place is generally selected for clipping. The straw-barn may be used for the purpose. The end next the chaff-house, between the two doors, is a good site for the clipping-floor, while the rest of the barn contains the sheep cool under cover.

Clipping-floor.—A clipping-floor is sometimes prepared in this way: Let clean straw be spread equally two or three inches thick, and then spread the large canvas barn-sheet over it, with its edges nailed to the floor. Thus a soft cushion is made for clippers and sheep. A broom sweeps the barn-sheet clean.

The barn-floor and walls, as high as the sheep, should be swept of dust, and straw strewn upon the floor for them to lie upon.

Upon large sheep-farms facilities are provided for clipping at the sorting-pens, where there is usually considerable shed accommodation.

In case of dew or rain in the morning, as many dry sheep are brought into the barn on the previous evening as the number of clippers will shear on the ensuing day.

Force at Clipping.—It is customary for neighbouring shepherds to assist each other. The emulation amongst a number of men clipping together not only expedites the shearing of the individual flock, but makes the work cheerful, and calls forth the best and quickest specimens of workmanship from each clipper. Many additional hands have to be hired or transferred from other farm-work for the occasion, the number required varying with the size of the flock.

The steward has no time to clip sheep, but the art is known by the hedger; and if the cattle-man has been a herd, he lends a hand. Clipping being dirty and heating work, the coat is stripped, and the oldest trousers put on, whilst some throw aside the hat, vest, and cravat. In some parts of the country women assist at the clipping.

Wool-shears.—The implement with which the wool is clipped off sheep is made of steel, in the form of *shears*, whose broad blades are connected by an elastic ring, as in fig. 403. The elasticity of the ring acts as a spring to keep the blades separate, and the pressure of

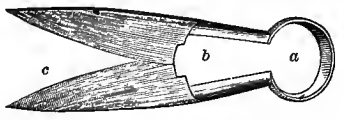


Fig. 403.—*Wool-shears.*
a Spring-bowl of shears.
b Rounded handles of shears.
c Flat broad blades of shears.

the hand upon the handles overcomes the spring and brings the blades together.

Some wool-shears have additional springs between the handles to separate the blades more forcibly, but are oppressive to the hand, which requires relief from a piece of cord wound loosely round the handles. Strong-springed shears are most easily worked if held at the blades; but the sharp backs of these soon hurt the hand. When not in use, and when carried, the blades are held together at their points by a ring of leather.

Sharpening Wool-shears.—The best method of sharpening is by the use of an oilstone, such as joiners commonly use.

The operator springs open the shears until the blades will pass each other back to back; then, gripping them firmly, he places the edge on the stone, holding the blade at a slight angle, and proceeds by a curving or circling motion to rub up the cutting edge. Simple as this operation seems, it demands considerable care and practice to do it really well. A good sharpener will not on any account allow another person to sharpen his shears.

A shepherd requires two or three pairs of small shears for trimming, and uses only large shears for shearing.

Avoiding Injury to the Sheep.—The shears are used in a manner not to injure the fleece or the skin of the animal. The particular to be attended to in clipping is to keep the *points clear of the skin* by gently pressing the blades upon the skin; for whenever the points are allowed to touch the skin, they will either run into

or make a large gash in it before the clipper is aware of the mischief he is doing. This is an error committed by new clippers, and it is done by holding the hand too high above the skin, and depressing the points of the shears into it. The sure way of avoiding this serious injury is to keep the hand low, and to rest the *broad* part of the blades upon the skin; and on drawing the skin a little tight by the other hand, the shears slide, as it were, upon it, while their points thread themselves through the wool and never come quite close together, the blades at their centre in the meantime shearing the wool with moderately long and frequent clips.

The round form of the sheep's body favours the action of the blades, in not admitting the shears to make long clips, and in keeping their points asunder, which, if not so kept, would clip the wool at an elevation in advance of the blades clipping the wool next the skin.

Fig. 404.—*First stage of clipping a sheep.*

a Left leg of the clipper.
b Fore-feet of the sheep under the left arm of the clipper.
c Left arm of the clipper holding down the fore-legs of the sheep.
d Points of the small shears clipping the short wool off the belly.
e Left hand of the clipper keeping the skin of the sheep tight for the action of the shears.
f Scrotum of the sheep.
g g Inside of the thighs of the sheep.
h Tail of the sheep.

The wool would thus be clipped at two parts at the same time. *Very* short clips make slow work, but slow work safely done is preferable to hasty slashing, with injury both to the animal and the fleece. Experience makes longer clips effective, but at all times short clips are the safest mode of using the shears.

Shear-cuts. — Careless or inexperienced shearers are very liable to make cuts in the skin of the sheep with the shears. Every cut, however small, should be at once dressed with tar, which, for marking purposes, is always at hand at the clipping process.

The object of washing sheep becomes apparent at shearing; for if the skin and wool are not clean, the shears grate upon the dirt and make bad work..

Method of Clipping. — A common method of clipping is described as follows: On catching a sheep, twigs on the wool and dirt on the hoofs are picked off by the clipper or shearer, as he is variously called. The first stage of the process is shown in fig. 404. After set-

ting the sheep on its rump, the clipper stands and leans its back against himself. Taking the shears in his right hand, and holding up the sheep's mouth with his left, he clips the short wool on the front and each side of the throat, round the neck and across the breast to between the fore-legs. Then resting on his right knee, placing the fore-legs under his left arm, he shears the belly across from side to side down to the groin. In passing down where the skin is naturally loose, the palm of the left hand pulls the skin tight. The scrotum is then bared, then the inside of the thighs, and, lastly, the sides of the tail. These are all the parts that can be reached in this position.

For the clipping of these parts, small shears suffice; and as the wool is short, and of a detached character, it is best clipped by short clips of the *points* of the shears. The sheep is somewhat un-

Fig. 405.—*Second stage of clipping a sheep.*

a Bared neck of the sheep.
b Left hand of the clipper keeping the skin of the sheep tight.
c Fore-legs of the sheep.
d Tail of the sheep.
e Right or clipping hand of the clipper with the large shears.
f Right arm of the clipper.
g Left arm of the clipper.

easy in this position, and many attempt to struggle.

The second stage in the clipping is shown in fig. 405. Its position for the sheep is gained by relieving its fore-legs from the first position in fig. 404, and, resting on both knees, the clipper firmly turns the sheep upon its *far side*, supporting its far shoulder upon his lap. The sheep now feels at ease, and will lie quiet to be clipped.

It should be borne in mind that, in shifting from one position of a sheep for another in clipping, a *firm* hold of the animal should be retained, else, on finding itself half released from constraint, it will attempt to start to its feet and be off. In such a burst, before the sheep can be caught and laid down again in its position, the clipped part of the fleece may be very much broken and ravelled.

Confining its head with his left arm,

the clipper first removes the wool from below the neck, and around the back of the neck to the shoulder-top, with the large shears. He then slips its head and neck under his left arm, and thus having the left hand at liberty, he keeps the skin tight with it, while he clips the wool with the right, from where he had just left off to the backbone, all the way down the near side to the tail. In the figure, the fleece is removed about half down the carcass; the left hand lying flat, keeping the skin tight; while the right hand holds the shears at the right part, and in the right position. The clipper thus proceeds over the thigh and the rump to the tail, which he entirely bares at this time.

The third stage—according to this method—is shown in fig. 406. It is attained by clearing the sheet of the loose parts of the fleece: the clipper, holding by the head, lays over the sheep on its clipped or *near side*, while still on

Fig. 406.—*Third stage of clipping a sheep.*

a Right ankle and foot of the clipper keeping down the head of the sheep.
b Right arm of the clipper clipping.
c Left arm of the clipper keeping the skin of the sheep tight with the left hand.
d Freed fleece.

his knees, and puts his right ankle over its neck, the ankle and foot keeping the sheep's head down upon the ground, the sheep lying quietly. The wool having been bared to the shoulder in the second position, the clipper has now nothing to do but to commence where the clipping was then left off, and clear the fleece off the far side from the backbone to the belly, the left hand still keeping the skin tight. The wool has to be taken off the far hind-leg onwards to the tail. The fleece is now freed from the sheep. In assisting the sheep to rise, care should be taken that its feet do not get entangled with the fleece, otherwise, in its eagerness to escape from the unusual treatment it has just received, it may tear the fleece to pieces.

Clipping with the Left Hand.—Others proceed quite differently in this last stage of the process. They would hold the shears in the left hand, and clip from the belly towards the backbone. Expert clippers can clip with either hand, and this plan makes neater work.

Another Method.—Another method, which is common in some parts, is more irksome both to the clipper and the animal than the system illustrated. In this other method the practice, in the first stage, is to place the sheep upright on its rump, while the clipper stands on his feet, supporting its back against his legs, and clips around the cheeks, neck, breast, belly, scrotum, to the lowest part of the animal, the tail. Standing all the time and bowing low, he puts himself as well as the sheep in an uncomfortable position. In the second stage, the clipper still stands on his feet, and the sheep upon its rump, while he secures its head between his legs, and tightens the skin of the near side by bending it over his knees. The skin is tightened at the expense of the ease of the animal, whilst bowing down low and long cannot fail to pain the back of the clipper. In the third position he keeps the left leg bent, resting on its foot—a more irksome position than kneeling on both knees.

Differences in Fleeces.—Some fleeces are much more easily clipped than others. Thin watery wool is not fit to be clipped in broad courses—the shears easily passing through it induces the clipper to

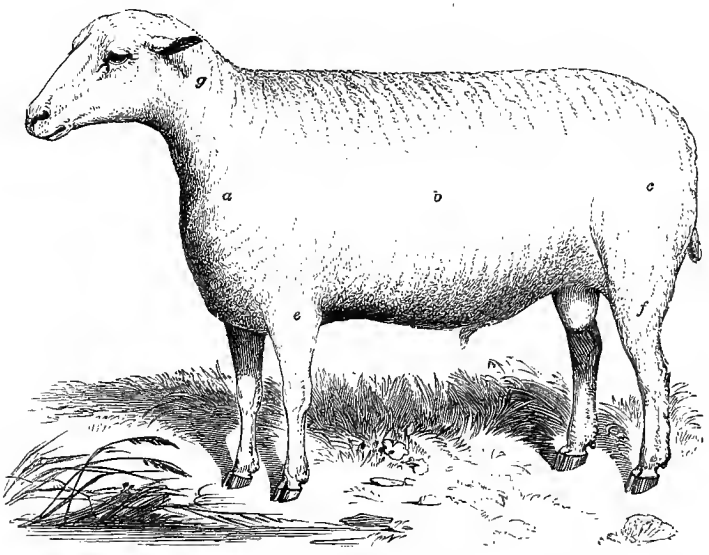


Fig. 407.—*New-clipped sheep.*

a Shoulder-point of sheep.
b Round rib of sheep.
c Hind-quarter of sheep.
e Fore-leg of sheep.
g Neck of sheep.
a to *e* Shoulder to fore-leg.
a to *g* Shoulder-point to top of shoulder.
c to *f* Hind-quarter to hind-leg.

take too broad a clip. Thick wool requires the shears to be employed mostly at the points, as these cannot penetrate it so far in advance of the blades as with wool in the ordinary state. Certain fleeces are so thick as to be *coated*—that is, felted on the sheep's back. These can be taken off only with the points of the shears in minute clips. Such fleeces are most easily clipped after a fresh growth of wool has taken place.

Number Clipped per Day.—To shear 25 to 30 sheep is a good day's work for any clipper, though there are shepherds who can do more. A fat sheep is more easily clipped than a lean one. As soon as one lot of sheep is clipped, another is brought to be ready to commence on the following morning.

New-clipped Sheep.—A new-clipped sheep usually looks like fig. 407. The shear-marks, it will be seen, run in parallel bands round the body, from the neck and counter along the ribs to the rump, and down the hind-leg.

When pains are taken to round the shear-marks on the back of the neck, connecting the space between the counter

and the top of the shoulder; to continue the marks from the shoulder down the fore-legs; to continue them from the hind-quarters, in the shape of the hind-leg, as far as the wool reaches; to make them run straight down the tail; to cause them to coincide from each side across the back,—a newly clipped sheep in good condition is a beautiful object, artistically treated.

A sheep clipped in a state of *perfection* should have no shear-marks at all—these marks being small ridglets of wool left between each course taken by the shears. But such a nicety of clipping is scarcely attainable, and not worth the sacrifice of time in doing it. It should be borne in mind that the closer wool is clipped to the skin the better it is for the next fleece, while a larger and heavier fleece with a longer staple of wool is obtained from each sheep.

Clipping on Hill-farms.—In most purely pastoral districts where the flocks are large, the method of clipping is slightly different. There the old-fashioned practice of tying the legs of the animal together, on the greensward in the open air, is still extensively practised. After the sheep is thus placed in a helpless state between the legs of the clipper, who sits on the grass with the head of the sheep towards him, the shears are made to ply, from the neck to the tail, in long slashes, so that the fleece may be snatched off in the shortest time. The legs are then loosened and the sheep set at liberty. Women are frequently employed at this work, to which there is no objection, provided they do it well; but it must be said that in this method the work is sometimes rather imperfectly done.

In some cases, where there are no sheds or other houses available, tents of canvas are erected. In average seasons, however, there will be little need for this. Than a thoroughly close, dry greensward there can be no better place for sheep-shearing.

Few pastoral farms are without a steading or sheds of some kind, and in wet weather these are available for the sheep-shearing.

Early Shearing Risky.—When cold weather follows clipping there is considerable risk of injury to the newly shorn sheep. Too early shearing is therefore undesirable; and when any sheep, such as rams, are shorn unusually early, they are kept in the house or where they have access to shelter till the weather becomes warmer. When cold wet nights follow immediately upon the clipping of the general flock, it is a good plan to place them under a roof or in some other dry and well-sheltered spot overnight.

Shearing Lambs.—In the extreme south of England, notably in Cornwall, the practice of clipping lambs has long been pursued. It is by degrees spreading northwards, and is considered by many flock-owners to be decidedly beneficial to the progress of the lambs. In the case of lambs which are to be fattened off in the course of their first winter or following spring, it is specially advantageous to clip them as lambs. Lambs' wool is usually in request at a comparatively high price. It is generally past midsummer before lambs are shorn. The practice, however, is still quite the exception in this country.

Sheep-shearing Machine.—A machine for shearing sheep, which promises to be of service where large flocks are kept, has been brought out in Australia by Mr Wolseley. It consists of a cutting-wheel geared to the shaft of a small steam-turbine, which is worked by a current of steam conveyed from the boiler in an india-rubber tube. A comb moves in front of the cutter, effectually preventing injury to the sheep. The shearing apparatus, which is made of brass, and is in shape similar to a small trowel, is held in the hand, and directed over the body of the sheep just as is the wool-shears. The clipping, however, is done much more rapidly, more cleanly and evenly, and with perfect safety to the sheep.

Tar-brand.—As the sheep are clipped, they receive the distinguishing brand, "buist," or tar-mark—noticed more fully under the heading of "Marking Sheep."

Mothering Lambs after Clipping.—There may occasionally be difficulty in getting lambs to take to their mothers after clipping, especially if the two have been kept apart longer than one day. This occurrence will be referred to in dealing with the weaning of lambs.

ROLLING AND WEIGHING FLEECES.

Wherever sheep are shorn — in the straw-barn, in a shed, or on the green-sward—a board is erected for rolling the fleeces upon as they are shorn.

Method of Rolling.—In many cases a smooth plain deal door is used for winding fleeces upon, and it should stand on tressels 2 feet above the ground, and 3 or 4 feet from a side-wall, near the clippers. A chaff-sheet should be spread on the floor close to the wall to pile the rolled fleeces upon until they are taken to the wool-room, at the end of the day's work. The person appointed to roll the fleeces must be accustomed to the work, for it has to be done carefully and neatly. Whenever a fleece is separated from the sheep, he or she lifts it carefully and unbroken from the shearing-cloth, and spreads it upon the board upon its clipped side, with the neck end farthest off. The folder then examines the fleece carefully, and removes any extraneous substances such as straws, thorns, whins, burs, or lumps of dung. Fig. 408 shows the mode of rolling a fleece, where a board

Fig. 408.—*Rolling a fleece of wool.*

a Board.
b c Tressels supporting the board.
d Field-worker rolling a fleece of wool.
e A fleece of wool placed on the board.

is supported upon the tressels, and a field-worker is in the act of winding a fleece.

Folding Rack. — Preferable to the close door for folding fleeces upon is a door or rack, made of narrow strips of wood attached on cross spars, and having an opening of about one inch between every two. This allows any dust or other similar substance adhering to the fleece to fall through in the process of rolling and folding. This rack-like folding door is placed upon tressels, as shown in fig. 408.

Keep Fleeces Clean.—The farmer should be particular in giving instructions to have every fleece as clean as possible. The purchaser cannot unloose every fleece he buys; and should he find as much filth in the fleeces, after purchasing them, as to warrant the belief that it had been purposely made foul, he may either relinquish his bargain, or make a large deduction from the price —in the former case implying fraud on the part of the farmer, and in the latter diminishing his profits.

Details of Folding.—The winder being satisfied of the purity of the fleece, folds in both its sides, putting any loose locks into the middle, and making the breadth of the folded fleece from 24 to 30 inches, according to its size. She then rolls the fleece from the tail towards the neck, tightly and neatly; and when arrived at the neck, puts a knee upon the fleece, while she draws out and twists the neck-wool in the form of a rope with both hands, of such length as will go round the fleece; and then holding the fleece tight at the lower end of the rope with one hand, removes the knee, still holding the end of the rope in the other, winds the rope tight round the fleece, making its end fast under the rope. The fleece, as a bundle, is easily carried about, having the clipped surface outside, which, being white wool saturated with yolk, has a silvery lustre. It is laid aside next the wall. Fig. 409 is a fleece of wool rolled up in the proper manner.

Where there are eight or ten clippers, with one person to catch the sheep, two women will be required to roll up the fleeces; one rolling and the other twisting the band, and keeping the floor tidy and clean.

Assorting Fleeces.—All fleeces are not alike, either in structure or colour. Those of ewes are thin and open in the locks, of pale colour, and feel light in the hand. Hoggs' fleeces are close, long in the pile, of a rich colour, bulky, and feel heavy in the hand. Fleeces in all parts have not the same completeness; one part may have been shed off in the field;

another *coated,* having the appearance of thick cloth; whilst several parts may have a dusky hue. Whenever such differences are observed, fleeces should be assorted and each class or grade sold separately.

Coarse stray locks, clotted with dirt, which are known as foot-locks, are thrown

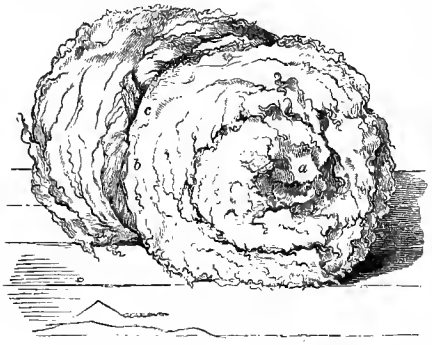


Fig. 409.—*Fleece of wool rolled up.*

a Centre of fleece, consisting of the wool from the breech of the sheep.
c Rope of wool from the neck of the sheep twisted round the body of the fleece.
b Body of fleece of wool.

under the rolling rack, and afterwards sold to one of the farm hands, who will wash and clean them for the wool.

Wool-room.—Each day's clipping is carried into the wool-room. Previous to being occupied, the room should be swept clean of dust from its plastered walls, and its wooden floor washed and dried. The fleeces are piled upon the floor at a distance from the walls, the hogg and ewe and other distinctive fleeces being kept apart, as assorted.

Each sort is covered with a cloth, and the shutters of the window closed. The reason for these precautions, which are not always attended to by farmers, is, that the cloths serve the double purpose of keeping off dust and preventing too quick evaporation of the yolk of the wool and the consequent diminishing of its weight, while the exclusion of light preserves the bright lustre of the wool. A damp wool-room causes the wool to clap together and to mould. A hot dry room scorches the wool.

Coated fleeces and locks of wool should not be brought into the wool-room at all. The coated fleeces should be sold at once, and the locks cleaned for use.

Wool-moth.—In spite of every precaution, the white-shouldered wool-moth, *Tinea sarcitella,* fig. 410, may come into the wool-room in a short time. This, as observed by Curtis, "has long been recorded as a most mischievous little moth in our dwelling-houses, where it is common the greater portion of the spring, summer, and autumn. . . . The female deposits her eggs upon cloths, blankets, curtains, carpets, or any woollen articles, on which the larvæ feed, living in cylindrical cases which they form of the materials on which they subsist covered with their excrement, and in which they change to pupæ. The caterpillar is a lively wriggling animal, about ½ an inch long when full fed; it is soft and white, with a yellowish tint, and sparingly clothed with fine longish hairs, sometimes having a slate-coloured stripe down the back, arising from the food; the head is horny, of a chestnut brown, and furnished with little strong jaws and minute horns."[1]

Wool is an unsafe article for a farmer to keep long. For a short time it becomes heavier in the room, absorbing moisture from the walls, floor, and air, which it probably does as long as it retains its vitality; for, being a living body

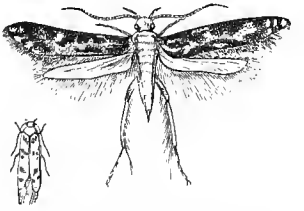


Fig. 410.—*White-shouldered wool-moth* (Tinea sarcitella).

when shorn, some time must elapse before it loses life. After life is gone, wool soon loses its natural moisture in a dry room, and the staples become curled and harsh; and in a damp room, after loss of vitality, the fleeces compress and feel clammy. The wool-moth then appears, and breeds numerous larvæ, which subsist on the staples, and cut them in pieces.

Many farmers have no wool-room, but keep their wool in a granary or outhouse, where these evils are aggravated.

Preserving Wool.—The best way of

[1] *Jour. Eng. Agric. Soc.*, vii. 429.

preserving wool for a length of time is to have it in a cool dry room with a wooden floor, and packed in sheets, in which it will be out of the reach of dust, light, and moths.

Disposing of Wool.—The safest plan for the wool-grower is to sell it every year at the current prices, which are determined at the great wool fairs in summer in every part of the country, either to wool-dealers at home; or to consign the entire clip to the wool-brokers (whose name is legion), to dispose of to the best advantage, at the proper time. When a wool merchant purchases wool from a farmer, he sends his own people to pack it in his own pack-sheets.

Weighing Wool.—Wool is weighed in this way: It is sold in Scotland by the wool-stone of 24 lb. avoirdupois, and is weighed out in double stones of 48 lb., each being called a *weigh*. In England wool is sold by the lb., and weighed out by the *tod* of 2 stones of 14 lb. each, or 28 lb. In weighing out, fleeces may not exactly weigh the double stone; and as fleeces are never broken to equalise the scales, a few small weights are in use to balance the scale on the side of the wool or weights at each weighing. In this way the weight of the number of weighs required to fill each pack is correctly noted.

In fig. 411 are shown the large scales and beam weighing wool. A man takes the fleeces from the pile, and, after weighing a double stone, places the fleeces in a heap on the floor. If the wool-room

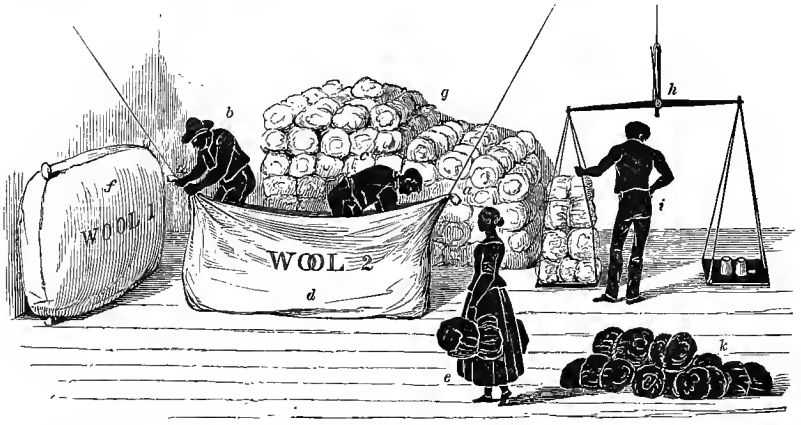


Fig. 411.—*Weighing and packing wool.*

a a Pack-sheet suspended by the corners.
b Man tramping fleeces in the corner of the sheet.
c Man placing a fleece in the corner of the sheet.
d Pack-sheet.
e Worker carrying weighed fleeces to be packed.
f Completed pack-sheet.
g Unweighed fleeces.
h Beam-scale for weighing fleeces.
i Man weighing fleeces.
k Weighed fleeces.

has a ceiling high enough to suspend the beam and scales from a hook, and large enough to pack the wool in the sheets, so much the better; but if not, the wool must be removed to a spacious enough place to be weighed and packed, and placed on clean barn-sheets.

Packing Wool.—Wool is packed in this way: Pack-sheets are made of thin canvas, doubled, of the shape of an oblong rectangle, about 8 feet long when empty, and open along one side. A small stone is placed in each end of the opening of the sheet, and a rope for each end being suspended from the ceiling, the stones form knobs which prevent the ends of the sheet slipping through the tyings of the ropes. The sheet just swims above the floor. Two men get into the sheet, one at each end, place the fleeces, handed to them by a worker from the heap, lengthways *across* its bottom, as the man on the right is doing; and they trample them down with force, especially at the ends, with both feet together; while both hands hold firmly by the end of the sheet under the tying, as the man on the left is doing. The second layer of fleeces is laid con-

trary to the first, along the sheet, two or three fleeces being placed parallel in the breadth of the sheet; but the ends of the sheet are filled with fleeces placed across as at first.

The sheet is thus filled with alternate layers of fleeces till it is full, when the packers come out, loosen the ropes, and, reserving the small stones for the next sheet, at once close the mouth of the pack.

Sewing Packs.—If the mouth of the pack were left open for a time, the elasticity of the wool would cause the fleeces to rise up above it and render the closing impracticable, unless a few of the fleeces were taken out. With the aid of hand-cramps, the two men at opposite sides bring the mouth of the pack-sheet together, and hold it closed with iron skewers. When a farmer is packing wool on his own account, common iron kitchen table-forks answer for bringing the mouth of a pack-sheet together, and keeping them close. Thus closed, the mouth is sewed up with packing-needle and strong twine, the skewers being removed as the sewing proceeds.

Contents of a Wool-pack.—A pack of wool contains 10 stones — that is, 240 lb.

Wool, as it is sometimes packed, is not placed regularly in the sheet—the fleeces being crammed in and trampled down as they happened to come into the hands of the packer. This is an objectionable method, for the staple of the wool may be broken by the treatment.

Peculiarities of the Fleece.

The wool on a sheep will, on close inspection, be seen to consist of different qualities. The coarser is found on the under, and the finer on the upper part of the body. The finest wool is upon the shoulder and along the top of the back to the tail-head; the next finest below the shoulders, along the ribs to the rump; the coarsest on the haunches and breast; and below the belly it is often so short and detached that it cannot be classed with the rest.

Subdivisions of the Fleece.—Each of these parts is divided into different qualities, which wool-staplers classify. These subdivisions of the fleece by wool-staplers are technical — such as prime-lock; choice-lock; picked-lock; super-head; head; downrights; second abb; livery; short-coarse or breech-wool. It would be well for wool-growers to have lessons from wool-staplers on the quality of the wool on different parts of the fleece, in order to be able to estimate the value of the fleece. According to present practice, wool-growers grow wool without knowing what it is fit for, and must take such prices as are offered.

Properties of Wool. — Good wool has these properties: The *fibre* is of uniform thickness from root to point, when it is said to be *true;* the finer the wool, the smaller the diameter of the fibre; the fibre is elastic on being stretched lengthways; tough, not easily broken; of great density, having a shining silvery lustre.

As to *staple*—the staple being any lock that naturally sheds itself from the rest —all the fibres should be of the same length, otherwise the staple will be *pointed;* the end of the staple is as bright as the bottom, and not composed of dead wool; the entire staple is strong. The strength of the staple is tested in this manner: Take the bottom of the staple between the finger and thumb of the left hand, and its top between those of the right, and, on holding the wool tight between the hands, make the third finger of the right hand play firmly across the fibres, as in staccato across the strings of a violin, and if the sound be firm and sharp, and somewhat musical, the wool is sound; if the fibres do not break on repeatedly jerking the hands asunder with considerable force, the staple is sound; if they break, the wool is unsound. It will most likely break at the place which issued from the skin of the sheep when the animal was stinted of food or had an ailment; and the greater the illness, the easier the staple gives way. Pliability is a good property in the staple; inflexibility and brittleness bad qualities.

Good Fleeces.—A good fleece has the points of all its staples of equal length, otherwise it will be pointy. The staples are set close together, and the fleece *clean.*

A pointy, watery, or dirty fleece creates much waste to the manufacturer, in bringing the wool to a proper state.

A good fleece has great *softness* to the feel, which does not depend upon *fineness* of fibre, but upon a delicate elasticity which yields to the touch at once, and quickly recovers its form.

Hair in Fleeces.—There should be no *hairs* in wool—the long ones are easily distinguished, and give the name of *bearded* to the fleece; short ones, soft and fine, are not easily distinguished, and are named *kemps*. Long hairs are of a different colour from the wool, but kemps are of the same colour; and of the two, the kemps are the more objectionable, as being less easily detected.

Injuring the Clip.—With all these properties in view, it would follow that the farmer who breeds sheep having fleeces with pointy staples, thinly set on, and of unequal lengths—who stints his sheep of food at times, producing wool of unequal size and strength—and (as many contend) who does not wash his sheep clean—or, having washed them clean, allows their wool to be dirtied before being clipped, and clipped before the yolk has returned to it—injures his clip of wool to a serious extent.

Composition of Wool.—The composition of wool, analysed by Way, is as follows:—

	Organic matters	63.1
	Ash	36.9
		100.0
	Nitrogen	4.3
	Ammonia	5.2
Soluble.	Potash, Soda, Chloride of potassium, Chloride of sodium	0.3
Soluble.	Sulphuric acid with salts	
Soluble.	Lime	15.4
Soluble.	Carbonic acid	12.1
Total inorganic matter.	Sand and silica	61.8
Total inorganic matter.	Salts of potash and soda	0.3
Total inorganic matter.	Lime	17.3
Total inorganic matter.	Alumina and oxide of iron	6.1
Total inorganic matter.	Chloride of potassium, Chloride of sodium, with salts	
Total inorganic matter.	Phosphoric acid	2.4
Total inorganic matter.	Sulphuric acid, with salts	
Total inorganic matter.	Carbonic acid	12.1
		100.0[1]

Woollen Rags.—The composition of woollen rags, analysed by Nesbit, is as follows:—

Organic matter	89.9
Ash	10.1
	100.0
Nitrogen	11.4
Ammonia	13.8
Sand and silica	16.9
Potash	4.1
Soda	2.0
Lime	15.1
Magnesia	1.5
Oxide of iron	20.0
Chloride of sodium	11.9
Phosphoric acid	15.6
Sulphuric acid	12.9
	100.0[2]

Weaning Lambs.

The time of the year for the weaning of lambs, like that of the lambing itself, is subject to great variation throughout the country. June, July, and August are the weaning months, southern arable farms coming first, and northern hill farms last. The most general time would be from the 10th of June till the 1st of August.

Voluntary Weaning.—As mentioned in speaking of wool-shearing, it sometimes happens that the older lambs do not take readily to their mothers after the latter are shorn. The change in the garments of the mother must no doubt surprise the youngster, and not a few of the stronger lambs that have learned to forage for themselves may absolutely decline to have anything more to do with their maternal parents. The tendency to this estrangement will be lessened by keeping the ewes and lambs apart only as short a time as possible. In stubborn cases the weaning may be regarded as finished, yet both the ewe and the lamb will require attention. Good pasture is all the lamb will require, with access to pure water and a lump of rock-salt.

Treatment of the Ewes.—When ewes are forsaken in this way—indeed, at weaning-time, at whatever date that may occur—the shepherd should observe the ewes carefully, lest any of them should suffer from a persistent supply of milk. If they are removed to close-eaten dry pasture, there will, as a rule, be little

[1] *Jour. Eng. Agric. Soc.*, xiii. 498.

[2] *Ibid*

danger; but in extreme cases it may be advisable to relieve the udder by drawing away a little milk by hand, taking care not to empty, but merely to slacken the udder.

Weaning on Arable Farms. — A common practice is to take the ewes away from the lambs, leaving the latter on their own pasture, and removing the ewes to the barest and driest pasture on the farm, where they remain until the supply of milk has disappeared. When the lambs are left on their old pasture they do not fret so much or so long as when put to strange quarters. Still it is desirable, for the sake of pasture, to shift both ewes and lambs, placing the youngsters on some piece of fresh succulent pasture specially preserved for weaning-time — neither new nor rank, but fresh, sweet, and succulent. This prevents the lambs from falling off in condition, and lessens the first great wrench their little hearts have met with.

Hill-pasture for Weaning Lambs. —Some flock-owners think it a good plan to send their lambs at weaning-time on to some rough hill-pasture for a week or two, their idea being that the astringent properties of this pasture acts as a useful tonic. Rough hill-pasture is often hired for the purpose, and the youngsters may be all the better of the change if it is of short duration.

Milking Ewes.—In former times it was customary in many places to milk the ewes in order to make ewe-milk cheese, which, when well made, is very nutritive (*vide* Roquefort cheese, p. 517). Then, when smearing was common, milk was sometimes drawn from the ewes to make a low-class butter to mix with the tar for smearing. The practice of milking ewes, however, has been discontinued in this country. It was injurious to the ewes. It hindered them from storing up the fat in the system, so very essential for ewes that have to face the storms of winter in upland situations.

After-treatment of Lambs. — The treatment in the way of feeding given to the lambs after weaning, will depend mainly upon the purpose for which the youngsters are designed. If they are to be fattened off early on the farm, or sold to others for this purpose, they are fed highly all along. Most likely they have been learned to eat all kinds of the common artificial food before being weaned. If not, they are taught this now—receiving a daily allowance of cake and grain on good pasture land.

Training Lambs to Artificial Food. —There is often great difficulty in getting newly weaned lambs to begin eating artificial food. A good plan is, when the "speaning brash" is off the lambs, to confine them, in lots of, say, fifty in a fold, where they will have access to water and artificial food, the latter being placed in boxes. After the first day they will begin to eat, and they then may have a run for some hours on pasture, and be again taken to the fold. In a few days every lamb will readily take to the boxes.

Fattening Lambs.—The rate at which the lambs are forced will, of course, be regulated to suit the time at which it is desired to have them ready for slaughter. In Hampshire and other parts in the south of England, where the fattening of lambs for slaughter at nine to eleven months old is extensively pursued, the system of feeding is most liberal and highly forcing. Until early turnips are ready, the youngsters have frequent changes — perhaps weekly — upon rich pasture, lucerne, and clover aftermath, with all they can well consume of cake and grain. Then on turnips they have artificial food and hay.

Store Lambs.—The lambs to be kept for breeding purposes or for fattening at a later time, are treated more moderately. When they have been weaned, and had a week or two on good pasture to get thoroughly on their own feet, as it were, they may be turned on to some poorer pasture, where they will have sufficient food to keep them growing at a full pace, yet not such feeding as will tend to fatten them. In feeding of store lambs a medium course should be steered. Forcing, as with the fattening lambs, would be injurious to the afterthrift of lambs intended for breeding purposes. Pinched feeding, on the other hand, would be equally mischievous, for it would lead to stinted growth and to slow maturity in the produce. There is need for good judgment at every turn in the management of live stock—at no point more so than in deciding as to the methods of treatment for the various classes of stock

to be used for the widely different purposes of fattening at an early age, and breeding with fattening at an older age.

Weaning on Hill-farms.—At weaning-time on hill-farms the ewes are removed to higher ground and barer pasture, where for a week or ten days they are watched constantly. In many cases the lambs are also put to the heath or high ground, where they can have access to water, for a week or so—care being taken not to leave them longer there than seems necessary to break them into their new order of life. Many farmers, on the other hand, disapprove of putting newly weaned lambs on to heath, moory, or high ground, for the reason that, if left for any considerable time there, they may sustain a check to their progress which may tell upon them for long after.

On many farms a specially good part of the pasture, green or well mixed, well sheltered, with access to running water, but free from dangerous "holes," is preserved for a few weeks to be used as a "weaning-ground." Here the youngsters are kept for two or three weeks—most probably until they can be replaced upon the ordinary run of the flock.

The usual plan where there are two "hirsels" of ewes on the farm, is to place the lambs of "hirsel" No. 1 on the ground of "hirsel" No. 2, and those of No. 2 on the ground of No. 1; so that when the ewes come back to their old ground, in the course of perhaps about a month, the ewes of the one lot run with the lambs of the other.

Drafting Lambs.—After weaning the lambs are drafted, so that the various classes may be assigned to the intended purposes. Most probably the stronger of the wether lambs and the greater number (the best) of the ewe lambs will be retained to run on the farm along with the old sheep until later in the season. The others may be sent to arable farms to be wintered on grass and turnips. Those kept behind are drafted to the low country, as the pasture becomes scarce on the high ground, and as the winter approaches.

Dipping Lambs.

As soon as practicable after weaning, the lambs should be dipped. This keeps them from keds, and also prevents the maggot-fly from injuring them.

The dip used is almost always arsenic in one form or other, diluted with certain proportions of water. As the water evaporates, the skin and fleece become impregnated with the crystals of arsenic, so that even if the lambs should be attacked by the maggot-fly the maggots may develop, but will be poisoned by the arsenic in the skin and wool before they have been able to do any appreciable harm. The dipping of sheep will be treated of more fully in a later section.

Care should be taken that lambs (or sheep either) should not be heated or fatigued immediately before being dipped. Many deaths have occurred from summer dipping in a heated condition. A good plan is to allow the lambs, after being brought down for dipping, to lie on their pasture undisturbed for a fortnight or so, and then take them up in lots and run them through the dipping-bath.

MARKING SHEEP.

Sheep are marked for the purposes of indentification and classification, in various ways and at different times. There are the farm or flock mark, the age mark, and the pedigree or breeding mark. To provide these, four distinct systems of marking are in use—ear-mark, tar-mark, keel-mark, and horn-brand. By different ways of impressing one or more of these marks, all the distinctions required may be easily secured.

Ear-marks.—These consist of small pieces punched out of the fore or back margin of the ear, a slit in the tip with a sharp knife, holes made with punching-nippers, or a combination of these marks, or studs fixed in the ear after the manner of cuff-studs.

One form of the punching-nippers is shown in fig. 412. An inverted hollow cone, having its small end sharpened to an edge, is employed to cut the hole—of any form, round, square, or triangular—out of the ear; and, to save bruising the ears in punching, a pad of horn is inserted into the straight under-arm, the pieces nipped out rising out of the orifice

of the hollow cone. Some prefer a clipping-tool to the punching-nippers for ear-marking.

Tar-mark.—The tar-marking, or *buisting*, consists simply of stamping a letter or letters, expressive of the initials of the name of the owner of the farm, or of both, on different parts of the body. The buist is made with a simple instrument such as that shown in fig. 413, made with a wooden handle, an iron shank, and a flat capital letter, as S, cut out of some kind of stiff metal, as copper or iron. The length of the implement is about two feet.

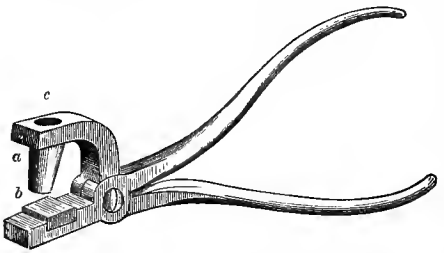


Fig. 412.—*Punching-nippers for sheep.*

a Hollow cone. *b* Horn pad.
c Orifice of hollow cone.

Fig. 413.—*Buisting-iron for sheep.*

The liquid for buisting is tar, made viscid by an addition of a little pitch, the two being boiled together in a metal pot.

As a rule the tar-mark is made high on the rib, so as to be easily seen — perhaps on the *near side* for female sheep, and on the *far side* on male sheep. Sometimes, for purposes of classifying the stock of different ages, breeding, &c., on the farm, the tar-mark on one lot is on the shoulder, on another on the fore-rib, and on another lot on the hip or hind quarter.

Keel-mark.—The keel-mark is made by red ochre mixed with oil, and, as with the other marks, it is put on at various spots on the wool on different farms, and to distinguish the one class from the other. The keel-mark, if well put on, is more easily seen at a distance than any of the other marks, and is therefore often very serviceable. Green keel is sometimes used for "hirsel" marks.

Horn-brand. — Horned sheep are marked on the horn with the owner's initials, or some other distinguishing letters, and perhaps also the year of birth and number in the flock register. A tool used for this purpose is shown in fig. 414. It is made wholly of iron, and on the upper face of the block is cut out as a die the capital letter to be used, as S. The length of the implement is about 18 inches. It is heated in the fire, and the letter burns its form on the horn. If heated high, it may brand several sheep before it cools, but the most uniform brand is made when the iron is heated for every sheep. To carry on the work expeditiously, two or three brands should be used—one to be in use while the other is heating in a fire hard by, to and from which a person carries the brands for the operator.

Fig. 414.—*Branding-iron for sheep and cattle.*

Branding is also sometimes done on the face of the sheep, but it is painful to the sheep, and may slightly disfigure the countenance.

Cattle are similarly branded on the horn and hide.

Marking Lambs.—As a rule, lambs receive the buist or tar-mark at the time of castration. In some cases they are then also ear-marked. In other cases the ear-marking may be delayed till a later time, perhaps till being sold, if they are to be sold as lambs, or until being sent away to the wintering ground. The wether lambs may not be ear-marked at all, but ewe lambs to be kept on the farm are always so marked. On some farms the female stock are marked on the *near* ear, and the male on the *far*. Thus, a single round hole is punched through the near ear of the ewe lambs, and a similar hole through the far ear of the wether lambs; and should any ewe lamb be considered fit for breeding-tups, it either receives an additional hole through the near ear, or a bit punched out of either margin, corresponding to a similar mark on its dam or sire, to dis-

tinguish its descent in blood. Twin ewe lambs receive a hole through both ears.

Tup lambs in many cases receive no ear-marks of any kind. Individual tups are so easily identified, and their descent so well known by the shepherd, that they may require no marking; yet it is far the better plan to have the distinguishing mark in all cases.

At weaning-time ewe lambs for sale are often *keeled*, perhaps on the neck, to distinguish them from the others.

Marking Older Sheep.—These receive the tar-mark at the clipping-time, each animal being *buisted* as it is relieved of its fleece. Later in the year, when the wool has dried sufficiently after dipping, the hoggs, wethers, and ewes may be *keeled*, the marks being differently placed so as to distinguish at a glance the different classes, such as draft ewes intended to be sold. Draft ewes are often also distinguished by a different tar-mark, perhaps merely a spot of tar put on with a round stick instead of the ordinary letter brand.

When a farmer purchases a lot of sheep it is the usual practice for him to stamp them with his own mark before placing them on the pastures.

Method of Tar-marking.—The following method of tar-marking or buisting sheep is often pursued: The sheep to be buisted are put into a convenient apartment of the steading, and handed out of a door, one by one, by a man, and held steady by another man holding the head and rump with his hands, and bulging out the side to be marked by pressing one knee against the side next him. The buisting-iron is dipped by a third person in the melted tar in the pot, lightly, to prevent dripping; and to make the buist vivid, he uses the buist with a considerable pressure equally upon the entire surface, flat upon the clipped wool, and withdraws it quickly. The wool must be quite dry, otherwise the tar will not adhere to it.

Registering Marks.—To facilitate the recovery of strayed sheep, the flockmasters in several counties and districts have introduced the system of registering their respective marks, and of publishing these in a book or pamphlet form. This is an excellent plan, especially useful in large pastoral districts where there is little fencing.

DRAFTING SHEEP.

When the ewes are dry or the milk leaves the udder, the flock are taken to the folds and "drafted"; that is, all the ewes which have attained a certain age, or are deficient in form or fleece, or have sustained any of the mishaps incidental to a breeding flock, or which are for some other reason to be sold, are separated from those which are to be kept.

Breeding and Selection.—The manner in which this work is accomplished—the care and judgment exercised in deciding which animal to sell and which to keep—makes all the difference betwixt a breeding flock of high quality which give character and similarity to their progeny, and a flock composed of all sorts and sizes, with no family likeness. The maintaining a flock, or the raising of it to a high standard, require great perseverance, patience, and firmness. Although the flockmaster may be aware of the general principles which underlie successful stock-breeding, he will most likely have to face many disappointments. This he must do with courage and perseverance, remembering that eventually *like will produce like*, without much variance, when his flock, by hereditary influence, asserts its *fixity of type*. The *best to the best* is a safe rule, and the results arrived at from this cause may not only lead to fame, but are also the most likely to lead to fortune.

This cannot be attained in the early development of a flock. The owner may have to wait years for the attainment of his ideal; but by a judicious selection of gimmers (shearling ewes) to make up his stock, his flock will always be getting nearer to the desired excellence.

Another point which ought to be always kept in view is, that any deficiency in form or fleece will most likely assert itself with greater intensity in the offspring, so that the breeding flock must be as nearly faultless as it is possible to have it.

Principles of Breeding.—The general principles of stock-breeding, thus briefly hinted at here, will be more fully treated of in another portion of this work.

A careful study of these principles will repay every flockmaster. Here it will suffice to say further that each flockmaster keeps in view the perfect sheep of the particular breed he owns, and retains for breeding only such of his young stock as come near to this type, aiming always at a higher and higher standard.

It is not meant that no young ewe, unless perfect, should be admitted into the ewe-flock. The object of the flockmaster should be to get his shearling ewes as free from faults as possible, and no animal should be taken into the breeding flock which may have very marked defects. A faulty head or a weak neck may be corrected by placing the animal to a male having these points strongly developed. There can be no doubt that faults of form or constitution in the parents are liable to crop up in the offspring; if not the first, very often in the succeeding generation.

Treatment of Draft Ewes. — The draft ewes on many farms are placed on the best grass available, which, with artificial food, quickly fattens them, so that they are generally all cleared off before the autumn. But when ewes are regularly cast from hill-farms at four years old, they usually find their way to lower-lying farms, and another crop of lambs taken from them before they are fed off —generally from rams of some of the earlier maturing Lowland breeds, such as Border Leicester, Shropshire, or Half-bred, the half-bred rams so largely used in the south of Scotland being crosses between the Cheviot and Border Leicester breeds.

Breeding Ewes.—The keeping ewes, old and young, are put on fair pasture, so that they may retain their condition, and so remain until within a month of putting them to the ram, when they are changed to better pasture, with the object of flushing them before service. This flushing, if judiciously done, will ensure a larger crop of lambs.

Hill Flocks. — On pastoral or hill farms the flocks are treated in a similar manner, except that often the draft gimmers which are deficient in size, but have all the other qualities, may be kept for another year before they are put to the ram. By this method of treatment they usually attain to a satisfactory size, and may become as good ewes as any on the farm, while they do not generally break down so quickly as those which are tupped in their second year.

Tup-yield ewes, or those which have aborted, are all disposed of in early summer.

Age for Drafting Ewes.—The age at which ewes ought to be taken from the flock has been a subject of much controversy. No hard-and-fast line can be drawn. Much depends upon the character of the pasture on the farm, which influences the state of the teeth of the sheep. The difficulty or otherwise of obtaining young sheep to make up the place of the draft must also be considered, while the class and management of the farm are likewise leading factors. On most arable farms the flockmaster rears his own ewes, and consequently is so far independent of outside influences. In a flock of say 500 ewes, he would require to have 130 suitable shearling ewes to keep his flock always up to a fixed standard.

Keep the Flock Young. — It is better, as a rule, to keep the flock young. There can be no loss in this, as the owner can obtain as much money for his draft ewes as he could procure for shearling ewes; that is, when he regularly casts at a certain age. A customer is never awanting for stock of this kind or character.

General Hints.

Lodging for Sheep. — Where the green land is limited, it is advisable to turn the sheep off this during the night. Indeed of their own accord sheep—that is, the breeds accustomed to high land —will gravitate towards high and dry ground for their lodging, turning their heads down-hill again early in the morning. This prevents the low and green land from becoming so foul as would be the case if the sheep spent the night upon it.

Exhausting Green Land.—But the pasturing of sheep all day upon one portion of the ground and lodging them on another overnight, has also the effect of tending to seriously exhaust the fertility in the former. The greater and richer portions of the droppings of the sheep occur during night and early in the

morning. The low ground pastured during the day is thus being impoverished and the high ground enriched. Where this has occurred to a great extent, measures may have to be taken to replenish the fertility of the deteriorated ground.

Saving Hay for Hill-farms.—Care has to be taken during summer to provide sufficient hay for the requirements of the flock in snowstorms. A general practice is to save or hain the enclosed park which had been used early in spring for weak ewes and lambs. There is usually an enclosure of this kind, extending to perhaps 6 to 10 acres for every "hirsel" of ewes, and sufficient hay should be obtained here for a flock of 500 ewes during an average winter. It is the duty of the shepherds to cut and secure this hay, and it is important that the work should be properly and seasonably attended to. The shepherds also provide hay for their cows in winter; this they generally obtain by saving some "haughs" or green patches during summer.

"Pining" on Hill-farms.—In the pasturing of hill-farms, especially in a dry season, care should be taken not to keep the stock there too long without a change. Hill sheep in such circumstances are liable to acquire a very destructive disease known as "pining" or "vanquish." This malady, which is most prevalent on soils overlying the granite formation, and in seasons of drought when the vegetation becomes very dry, is supposed to be caused by alkaline poisoning arising from there being too great a proportion of potash and soda in the soil. The best remedy is an immediate change to soil and pasture of a different character—to low ground, if a sufficient change cannot be had on high ground.

Care against "Rot."—But in sending sheep from high ground to escape "pining," and in grazing all flocks on low ground, care must be taken to guard against the acquiring of that still more deadly disease known as "rot." This, with other ailments, will be dealt with subsequently in a special chapter. Here it will suffice to say that the flukes which cause the "rot" are most liable to be picked up on low, damp land, in wet or moist weather; that there is little danger upon dry land; that salt is a useful remedy; and that after the first severe frost the whole of the farm, high and low, may be grazed with impunity in so far as the liver-fluke is concerned.

PASTURING CATTLE.

The cattle which have been fattening during winter will be gradually drafted away for slaughter, so that by the end of April there will be few animals of the cattle kind on the farm except those which are to be grazed at least for some part of the season. At this time—the time of transition from the winter to the grazing season—the farmer has to consider and decide as to the stocking of his farm during the coming summer—what stock he is to carry on to the grass, and what should be disposed of. The chief conditions to be considered are the probable supply of summer pasture, the present and prospective prices of lean and fat stock, and the probable prices of extra food, in case such should have to be procured to supplement the supply on the farm.

Study the Markets.—It is especially important that the farmer should carefully study the tendencies of the market at this time. If beef should happen to be cheap and store cattle dear, he may find it advantageous to hold on a number of his partially fattened cattle to be finished on the grass, and sold perhaps in the month of June—that is, instead of selling these when the winter food is exhausted, and buying lean or store cattle when the supply of pasture becomes plentiful.

It very often happens that beef is scarce and dear in the first five or six weeks of summer. The winter-fed beasts are pretty well cleared out by the end of April, and grass-fed animals are seldom ready for slaughter before the advent of July. It will therefore often pay a farmer to hold over a few of his partially fed cattle to be finished on the grass with cake and meal, and sold in the month of June.

But in this as in other farming matters, the ruling conditions vary with every season, and no prudent farmer would

follow hard-and-fast rules in a blindfold fashion.

Keep Stock Progressing.—There is one point which demands most careful attention about the end of spring and beginning of summer. It is this—to see that the animals are carried from the one season to the other in a steadily progressing condition. Do not on any account let the animals fall off towards the end of the house-feeding season. If the supply of turnips and other home-grown food becomes scarce, buy in food, or reduce the stock by selling. Then if the supply of grass should be deficient at the outset, supplement with other food—with purchased corn and cake, if need be. In the period of transition from one season to another, cattle are often allowed to fall back in condition. This is very detrimental to the interests of the stock-owner, and should be avoided by hook or by crook.

Give the Pasture a Good Start.—Do not be impatient to turn the cattle from the winter quarters to the summer grazing. Let cattle of all ages remain in the steading until the grass is quite ready to receive them, and able to maintain them in a satisfactory condition. In late seasons, when the turnips and other winter food are exhausted before the grass can afford them a bite, the animals should be partly supported upon extraneous food—as oilcake, beans, oats; or those in fairly good condition should be disposed of, to leave some turnips for the young cattle and cows until the grass grows up.

The cattle are let out in relays as the grass grows up. It is a good plan at the first of the grazing season to take up the cattle at night, and give them dry fodder. This tends to counteract the laxative influence of the fresh grass.

Cattle should not be let on to pasture while there is frost in the soil, as they are then liable to injure the grass with their feet.

Overgrowth of Pastures Injurious.—An important point in the successful grazing of land is to keep the pastures from growing too rank. In the earlier part of the season, in particular, they should be well eaten down, cropped frequently, but not so as to injure the plants. Pasture-grasses should never be allowed to mature and produce seed, for both the land and the plants will be thereby impaired in their productive powers. Pastures do best when grazed for about two weeks, and rested for a similar period all through the season.

All kinds of stock thrive best on moderately short pasture. Rough bunches of grass should be regularly cut down by the scythe.

In some cases, in a good growing season, it may be advisable to buy in more stock to keep down the pasture. Others, especially when cattle are dear, save a portion for hay, and thus curtail the grazing area.

In some cases the droppings of the cattle are daily collected into heaps, and in the autumn spread upon the inferior parts of the field. Others merely scatter the droppings over the field, once or twice a-week.

Grass as Food for Cattle.—In confinement cattle thrive better on a variety of food; whereas on grass they require no further variety than nature supplies in good pasture, and they thrive the better the longer they live upon it, provided they are changed frequently to a fresh pasture. Grass is evidently the natural food of the ox, and his anatomical structure is peculiarly adapted for it. Whatever kind of food he receives in winter, partakes of an artificial character; and being only a substitute for grass, artificial food should be made as palatable as circumstances will allow, whether in variety or superior quality.

This consideration prompted Boussingault to adopt hay—grass deprived of its superfluous water—as the standard for comparing the nutritive properties of different sorts of food.

Changing Stock on Pastures.—Grass-land requires skilful management to make it most available as pasture in every sort of season. The circumstances under our own control which most injure grass are *overstocking* and *continual stocking*. To avoid overstocking, there should be no more stock upon the farm than its grass will maintain in good condition; and to avoid continual stocking, the stock should not be allowed to remain too long in the same field.

The safest way to treat each grazing-field is to stock it fully at once, in

order to eat it bare enough in a short time, and then to leave it unstocked for two weeks or so, that the grass may grow up to a fresh bite. One advantage of this plan is, that it provides new-grown grass; and another is, that the grass never becomes foul by being constantly trodden upon. Stock delight to have fresh-grown grass: and they loathe grass which has been trampled and dunged upon, times out of number.

To facilitate the frequent changing of stock to fresh grass, many farmers run a temporary wire-fence across a pasture field, letting the animals crop first one division and then the other.

Mixed Stock on Pastures.—Another principle affecting the treatment of pasture-land, is the different way in which different animals crop grass: cattle crop high, sheep nibble low, while horses bite both high and low. This is a wise distinction between the two classes of ruminants, sheep being suited to short mountain-pasture, which their mobile lips hold firmly while it is severed from the ground with the incisors of the lower jaw with a twitch of the head aside; whereas the ox is as well suited to the plains and valleys, where grass grows long, and which it crops with the scythe-like operation of its tongue and teeth.

From these different modes of cropping grass, it is inferred that the horse or sheep should follow the ox in grazing, or accompany him, but not precede him. On pasture eaten bare by horses or sheep, the ox cannot follow them; and when all are in company, the horse and sheep will eat where the ox has eaten before, or the horse will top the grass before the ox, the horse being fond of seizing the tops of plants by his mobile lips, and pinching them off between the upper and lower incisors. The accompaniment of them all in the early part of the season is a good arrangement, because all have the choice of long and short grass; but the horse should be separated from the sheep in the latter part of the season, as both bite close.

It is curious that horses, and workhorses in particular, have a great dislike to sheep and not to cattle.

Rules for proportional pasturing of stock are thus given by the Rev. Mr Beevor: "The sheep-pastures should have one young steer to twelve sheep; the bullock-pastures, one horse to every twelve beasts. The sheep-pastures should be kept comparatively bare; but the bullock-lands must have a good bite, so that the animals may quickly feed and soon lie down to rest and ruminate. An old grazing rule is, that grass should be twenty-four hours old for a sheep, and twelve days old for a bullock."[1]

Stocking.—A disturbing element in reckoning the number of animals that may be kept during the summer is the uncertainty as to the suitability of the season for the continued growth of grass. The usual plan is to reckon upon an average, and to arrange the number of stock accordingly. In the event of a bad grazing year, the stock may either have to be reduced by sales, or hay and artificial food may have to be purchased. On the other hand, superabundance of grass does no harm; for besides maintaining the stock in high condition during the grazing season, it will afford rough aftermath for the sheep in winter. On farms where stock are purchased every year, the number may be regulated by the state of the grass; but even then the season may turn out better or worse than expected.

Seeing that no one can foretell the future supply of pasture-grass, the prudent plan is to keep the number of stock under the mark which the farm can well support. An obvious lesson is to have the land always in good heart, as it will be the less affected by an adverse season.

Water and Salt.—The importance of having pure water within the reach of stock on pastures has already been referred to (p. 432). The opportunity of licking rock-salt is also relished by stock (p. 433).

Shelter on Pastures.—The want of a *shed* in a pasture-field is a reflection upon the sagacity of our farmers. In summer, where a tree spreads its branches over the grass in a lawn, how gratefully cattle resort to the shade, where they know that the stirring breeze will cool their hides, and afford them a refuge from flies! In cold weather, cattle crowd to the wooded corner of a field, and in a rainy day take

[1] *Jour. Royal Agric. Soc. Eng.*, xviii. 334.

shelter behind trees and hedges. Such indications by our animals should teach us how to treat them. We dislike hedge-row trees on account of the injury they do to the crops and fences near them; and still more dislike large trees in the middle of a cultivated field. There are many fields well sheltered on one side by trees, but this is not enough.

A shed should be erected at a suitable part to afford shade in the hot days, and shelter in a rainy or cold night. Such an erection would cost little where stone and wood are plentiful on an estate. It should be placed on either side of a fence when a field is in grass. No matter what it costs, it should be provided when the health and comfort of stock are concerned. Its cost would be repaid by the healthy state of the stock in the first or second year of its erection, and it would stand, with slight repairs, for many years. Let it be roomy, and its structure light, with a roof of corrugated iron or tiles.

It is troublesome to carry straw for litter from the steading to a shed situate at a distance. There is little need for litter in summer, however, and the rough grass from an adjoining wood or ditch is good enough for the purpose. The dung can be shovelled up and removed before it accumulates to the discomfort of the animals.

Apportioning Pasture.—The first point is the judicious distribution of the pasture amongst the various classes of stock to be grazed. In this matter there is scope for good judgment, for the returns from the grazing season may be largely affected by the manner in which the pasture of the different ages and qualities has been allocated to the various classes of stock.

Beginning Cattle on Pasture.—When cattle are first turned out to grass, they may so gorge or over-eat themselves as to become *blown* or *hoven*—an ailment which demands immediate treatment. To avoid this, the best plan is to begin the cattle gradually with the succulent pasture, which may be effected by giving the cattle a feed of some dry food daily for a few days before turning them on to the pasture, or by allowing them only a partial feed of the pasture for the first day or two.

Fattening on Pastures.

Animals to be fattened off early will, of course, have the best pasture—not perhaps the rankest, but pasture which is sufficiently well grown to afford a full bite, and which is known to possess the best fattening properties. Here the cattle will most probably also receive artificial food—the giving of extra food and the quantity being regulated by such conditions as the quality of the pasture, whether capable of fattening by itself, the condition of the cattle, and the time they are to be finished for slaughter.

There are few pastures capable of fattening cattle without the aid of cake or grain—only some of the choicest pastures of Ireland and the south of England. By the aid of cake and grain, however, cattle may be fattened upon all the average pastures of our good arable farming districts. Whether it will be more profitable to fatten on the pastures than to merely keep the grazing cattle in good progressive condition, to be finished by winter fattening, will depend upon conditions which must be considered in each individual case.

As a rule, fattening pays on the richest grazing land, known to possess high fattening properties. On the other hand, upon medium and poor land it is usually safer to simply graze the animals well, and not attempt the more expensive plan of finishing for the pole-axe.

For fattening cattle in particular, frequent changes to fresh pasture is highly beneficial.

Artificial Food on Pastures.—The artificial food given to cattle on pastures consists largely of linseed and decorticated cotton cake. It may often be found cheaper and better to use a mixture of cake and grain, the farmer taking care to buy whichever variety of food happens to be cheapest at the time.

For fattening stock on pasture, from 4 to 6 lb. per day of cake and corn are general quantities. Decorticated cotton-cake is largely used. It is difficult to feed meal to cattle on pasture without some portions of it being lost. The size of the cattle and the supply of pasture must be considered in deciding as to the quantity. It may be sufficient to begin with even

less than 4 lb., and increase as circumstances seem to indicate.

The artificial food should always be given in shallow boxes which cannot be easily turned over. It is a bad plan to scatter cake upon the grass, as is sometimes done. The boxes are shifted every day, so as to ensure, as far as possible, the even manuring of the land by the droppings of the cattle, and to prevent the grass from being spoiled by frequent treading on any one spot.

By the consumption of artificial food on land, the fertility of the soil is enriched; and in many cases this system of manuring land is extensively practised.

Most people give the artificial food in the morning, some early in the afternoon, and some in the evening.

It is a good plan, to prevent stock from falling off when put out to grass at the first of the season, to continue for a week or two, according to the supply of pasture, a portion of the artificial food they had been receiving in the house. Many farmers thus give their young store cattle a couple of pounds of cake, or cake and grain, daily for a fortnight or so after they are put on the pasture fields. When the supply of grass is plentiful, this, of course, is unnecessary.

Summering Cows.

Cows in milk must also have good pasture. Indeed, where no cattle are being fattened, the cows giving milk will probably have the best pasture on the farm.

Cows in summer are treated in an opposite manner by different people—one putting them into the byre at night, and milking them there in the day; another causing them to lie out all night, and milking them in the field. Whichever mode is adopted, it should be borne in mind that cows are peculiarly susceptible of injury from sudden changes of temperature—their produce of milk being suddenly reduced by exposure even for a few hours to an outburst of cold, wet weather. On the approach of unfavourable changes in the weather, the cows should be brought under cover.

At any rate, for some time after they are put out to grass, they should be brought to the house at night, where they are then milked, as also in the morning before being sent to the field. If they are milked at mid-day as well, this intermediate milking is done by some in the field and by others in the house. As a rule, in dairy districts cows are milked twice a-day—morning and evening; and in breeding districts three times a-day—morning, noon, and night.

Night and Day on the Field.—After the nights become warm, we have found it conducive to health in breeding cows to have them in the field all night—the shepherd or cattle-man bringing them to the most convenient part of the field to be milked. Milking in the field imposes more labour on the dairy-maid and her assistants, in carrying milk to the calves, and to the dairy; nevertheless, many consider it an excellent system for the health of the cows.

The cows rise from their lair at daybreak, and feed while the dew is still on the grass; and by the time of milking arrives—6 o'clock—they have partially filled themselves with food, standing contentedly chewing the cud, while the milking proceeds. By 9 o'clock they lie down in a shady part of the field, and chew their cud until milking-time arrives at noon, when they are again brought to the same spot to be milked. Feeding again, they go in the heat of the afternoon to the coolest part of the field, whisking away the flies with their tails and ears. As the sun wanes, they walk about picking up a mouthful till the evening milking takes place about 6, after which they feed industriously, and take up their lair about sunset, chewing their cud, and at daybreak rise and resume the daily round.

Does Dew-laden Grass injure Cows?—Apprehension does exist that cows injure themselves by eating grass wet with dew. Yet it is a fact, which is not so well known as it should be, that bedewed grass before sunrise, and grass after it is dried by the sun, are alike good for cows. It is only when the dew is being evaporated, after sunrise, that grass proves injurious. Cows which lie out all night eat the grass while it is yet wet with dew; whereas those in the byre, after being milked, are let out just at the time the dew is being evaporated by the sun, when the grass is in the coldest state. Hence cows kept in the byre

at night are more liable to be injured by eating dewy grass than those lying out overnight. Being hungry when let out, the former eat the cold damp grass with avidity.

Consider the Climate and Weather.—Locality, the character of the weather, and the local conditions as to shelter, should rule the custom of lying out or housing at night. In cold upland districts, or exposed situations devoid of shelter, so susceptible creatures as milk-cows should not lie out at night; and in the very few really warm nights in such situations, the byre might be ventilated. In favourable situations, this circumstance is worthy of attention in determining between lying out and housing, that housing causes the providing perhaps of supper, and certainly of litter, for the cows; and the provision implies cutting and carrying the forage, and rearing the plant in the field, and storing up straw for litter.

In warm weather, with strong sunshine, it is a good plan to keep dairy cows in the house during the day, feeding them on green food, and turning them out to the pastures overnight.

Excepting a change of pasture—and the change should be to a better one—the treatment of cows is the same throughout the summer, and until the advent of the cool evenings at the end of autumn. As the milk falls off, the noon milking, where such takes place, is dropped; and when the evenings become cool, the cows are brought into the byre at night, milked there evening and morning, and grazed during the day. Whenever housing takes place, supper must be provided for them after the evening milking is over, as also litter. Should the straw be exhausted, many light materials answer the purpose of litter—as coarse grass from plantations and bogs, ferns, sawdust, or peat-moss litter.

Serving Cows.—The cows of a breeding stock will mostly have been served by the bull before going out to grass. The cattle-man should attend to this matter, and enter the date of the service of each cow in his note-book.

Dairy Farms.—On farms where dairying is the chief or a leading feature, the whole system of cropping is arranged with the view of providing abundance of food for the cows all the year round. The cows have the best of the pasture in summer, and will also most likely receive additional food in the shape of linseed-cake, bruised oats, and bean-meal, or green forage, such as vetches, clover, and grasses, grown for successional cutting. In some cases they get the cake and grain on the pastures, but more frequently when taken to the house to be milked.

Dairy cows are fed with great liberality, the foods known to encourage milk-production forming a large portion of the daily allowance.

Water for Dairy Cows.—Access to fresh pure water is a matter of great importance to dairy cows. Cold spring water is objected to by many for this purpose. Running water which has been mellowed by exposure to the air, just cool but not chilly, is considered best for cows giving milk.

Avoid over-exertion for Cows.—The milk-production of cows is liable to be seriously impaired by over-exertion, as well as by imperfect feeding or exposure to cold. They should be walked leisurely between the house and the pastures, and the shorter the distance they have to walk the better it will be for the cows. In warm weather insects greatly disturb cattle on pastures, and to avoid these, many farmers take their cows to the house for a few hours in the hottest part of the day.

Mr Gilbert Murray on Grazing Dairy Cows.—On this subject Mr Gilbert Murray, Elvaston Castle, Derby, writes: "There are few farms on which dairy cows are kept where artificial foods of one kind or another are not used. Meal and a mixture of cut hay or straw are fed in the stalls at milking-time morning and evening. This counteracts the watery character of the grass, and keeps up the quality of the milk. Dairy cows are especially susceptible of injury from sudden changes of temperature and over-exertion or ill-usage of any kind. For them an even temperature and quiet kindly treatment are of the utmost importance. An acre of good grass land will produce from 1500 to 2000 lb. of milk, and by the use of artificial food this may be considerably increased."

Town Dairies.—In and around towns

it is the common practice to keep dairy cows in the house all the year round. Their food in summer consists largely of fresh grass and other forage, which is cut daily and given to them in a green, succulent condition, along with cake, bean-meal, and brewers' grains and bran.

Many of these dairymen, however, knowing the benefits to cows of a turn on pasture, rent small fields, and put their cows on them for a few hours daily, or perhaps overnight in warm weather.

Carse and Suburban Farms.—Grazing cattle in the ordinary sense of the term rarely forms part of the system pursued on carse farms or farms near large towns. The grazing on these farms is confined mainly to the work-horses and the milk-cows of the farmer and the farm-servants. On carse farms the new grass is, as a rule, kept only one year, and is chiefly used for forage and hay. On farms near towns the grass is sold for forage to cowfeeders and stablers.

Pasturing Young Cattle and Calves.

Young store cattle require little tending while on grass. Nevertheless the cattle-man, on going his daily rounds, should see that the young beasts are in good health, have plenty of food, plenty of water, and are in security within the fences. Like the other stock, they should have frequent changes to fresh pasture—every three weeks if possible. After a change to fresh pasture, they will thrive much faster, while the grass itself "goes further" by being cropped and rested alternately for two or three weeks at a time.

The young cattle, mostly into their second year, usually get the poorer pastures; yet they should have abundance of food, to keep them at full and steady progress. Shelter (from sun and wind), rock-salt, and pure water must also be within their reach.

Artificial Food for Store Cattle.—In reference to the use of artificial food in the grazing of young store cattle, Mr Gilbert Murray says: "Store cattle are usually grazed on second-rate pastures, and in no case is artificial food more profitably employed than for these on the grass. This not only hastens the growth of the animal, but at the same time, by the residue of the food in the droppings, enriches the soil. Without the assistance of artificial food, young growing stock impoverish the soil. This is well known to experienced graziers, who affirm that by *storing* the best fattening pastures for a few years they may be reduced to the level of ordinary store pastures; while, on the other hand, store pastures situated on suitable geological formations, may, by good management, be raised to the position of feeding pastures. It is needless to say how important it is to keep the young animal in a state of steady progression. When young growing animals are kept on food which is not sufficiently nutritious, or which is deficient in quantity, their organs of digestion and assimilation are liable to be so impaired that no after-treatment, however skilful and liberal, will fully repair the injury.

"A healthy animal of a good class should, at the age of from one to two years, on pasture increase in live weight at the rate of from 1½ to 2 lb. per day. This rate of increase, however, will seldom be attained without the aid of artificial food. For growing stock we prefer a mixture of meals of the home-grown cereals, including a small proportion of linseed. The main difficulty is in feeding these meals on the pasture without losing any portion of them. The best plan is to give them mixed with cut hay or grass. The hay, although not always palatable to the animals on pasture, is nevertheless a valuable corrective to the laxative tendency of the succulent grass. The quantity of the meal may vary from 1½ to 4 lb. per day. Decorticated cotton-cake may be used with less trouble, but with it there is a certain amount of danger, owing to the hard cake impeding the action of the digestive organs, and resulting in inflammation, not unfrequently in death."

Calves on Pasture.—Calves are put on grass at the same time as the other cattle, whether weaned or not. By that time the oldest ones will be ready for weaning; but although ready, the herd of calves should be kept together at first, in a paddock of grass near the steading, where the younger ones are still served with milk or other liquid food, while the older eat the grass, and both are put into

the shedded court at night, until the weather becomes warm enough to permit them to lie out all night.

Calves are very susceptible of cold, especially when on milk, and receive more injury from exposure to it and to wet than most breeders seem to be aware of.

Weaning Calves.—This important work in breeding stocks has already been dealt with. See Divisional vol. iii. p. 45.

Pastoral Farms.—On *cattle-pastoral* farms, the calves go with their dams, and partake besides of grass. Calves thrive well in this way, and attain to a large size. But if the cow does nothing more than breed and rear the calf, the system is not likely to be profitable.

The young cattle on pastoral farms graze on the low and sheltered parts till the weather becomes less stormy and cold in the upper parts, when they stretch their walks by degrees until the highest points are attained.

Purchasing Young Cattle.—Young cattle are purchased from the pastoral and breeding farms for the arable districts where few are bred, just before the grass is ready to receive them. Not unfrequently arable farmers hire grass parks for the season, and stock them with young cattle on speculation.

Young cattle for grazing should have all the symptoms of health and constitution—a clear eye, dewy nose, large frame, glossy long hair, although low in condition. A low condition is likely to be a greater loss to the breeder who has half-starved them, than to the purchaser who puts them upon good pasture on sound feeding land. Many requisites are to be attended to in purchasing young cattle. To be a good thriver and attain condition, the hair should feel mossy, and the touch of the skin mellow. The skin should not be too thin, nor feel hard and tight, and it should be covered with abundance of hair. Each lot of young cattle should be of the same or similar size and appearance. This uniformity is an enticing property in every lot of cattle. It is a lesson to the seller, in preparing cattle for the market, to assort them in lots of equal levelness.

Treatment of Bulls.

The rearing of calves intended for bulls has been dealt with under the heading of "Calf-Rearing," in Divisional vol. iii., and referred to more particularly on page 44.

When a number of bull-calves are brought up together (after weaning) they should be grazed by themselves on the best grass the farm affords, or with the ox-calves, while the heifer-calves go with the cows. Anyhow, they should never accompany the heifer-calves. A single bull-calf may go with the cows or with the young oxen.

Ringing Bulls.—Bulls should have a ring put into their nose before they are a year old. This instrument is useful not only in leading them, but of keeping their temper in subjection, and affording a more complete command over the most ungovernable bull than any other contrivance. In case a bull becomes irritable and troublesome as he advances in years, which is often the case, the ring furnishes the means of curbing him at once. The ring also affords an easy means of suspending a light chain from it to the ground, upon which the bull tramps whenever he runs towards a person, and by thus suddenly jerking his nose he checks himself. A young bull may follow a person in sport, which he should not be allowed to do, as the following may terminate in a run in earnest. It is best not to go in the way of a bull in a field, especially when he is with cows. He does not mind the dairy-maids when they come to milk the cows, nor the cattleman, or the shepherd and his collie, for he becomes familiar with them.

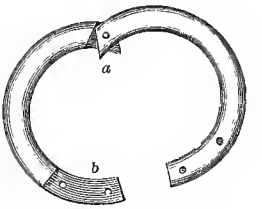


Fig. 415.—*Opened bull's ring.*
a Joint with rivet.
b Lapped joint for the screws.

Rings for Bulls.—A common form of ring for a bull is shown in fig. 415. The opened ring is passed through the hole in the bull's nose, and then screwed close as a round ring. Fig. 416 shows the ring screwed together as it hangs in the bull's nose—the joint closed, and the lapped ends also closed, with the countersunk screws flush with the surface of the ring. The ring is of quarter-inch rod-iron or

brass, and its diameter over all is 2½ inches. The surface is smoothly filed and polished.

Process of Ringing.—The ringing of bulls has to be carried out with great care, so as to excite the animal as little as possible. Formerly the hole for the ring was generally made by a hot iron, and with that system the process was described as follows, in the former editions of this work:—The operator is provided with an iron rod about a foot long, tapering to the point, and rather thicker than the rod of the ring. Let a fire be near to heat the point of this rod. The operator should also be provided with a small screw-driver. Let a long strong cart-rope be provided with a noose hitched upon the middle, just large enough to take in the bull's neck, like a collar. Put the bull into any outhouse that has a window sufficiently low to allow his head to reach through it, though it is safer for his knees against the wall to press his counter against a strong bar of wood. Slip the top of the loop of the rope over his head down to the counter, bring his breast against the window, pass the rope from the lowest part of his neck along the ribs on each side round his buttocks, like a breeching, and bring an end through the window on each side of the bull, where a man or men hold on to each end of the rope, to prevent the bull retreating backwards from the window. A man stands on each side of the bull's buttock, to prevent him shifting to one side or the other. A man also stands on each side of the bull's head, holding on by a horn, or by an ear if he is hornless, with one hand, and keeping up the nose by supporting the lower jaw with the other. The operator having the iron rod given him by an assistant, heated in the fire just red enough to see the point in daylight, takes the bull by the nose with his left hand, and feeling inwardly with his fingers, past the soft part of the nostrils, until he reaches the cartilage, distends the orifice of the nostrils, so that the hot iron may pierce clear through the cartilage without touching the skin of the nostrils or his own fingers, the operator taking care to pass the iron in a direction exactly parallel to the front of the nose, otherwise the hole will be pierced obliquely. Immediately after the tapering rod has been passed as far as to make the hole sufficiently large for the ring, and the wound seared enough, the operator removes the rod and takes the ring opened, still holding by the bull's nose, passes one end of it gently through the hole, and, on lapping the two ends together, lets go the nose with the left hand, and taking hold of the ring with the same, still to command the bull, puts one screw in, then the other, securing each in succession firmly with the screw-driver. He then turns the ring round in the hole, to feel that it moves easily, and to see that it hangs evenly, after which the bull is released.

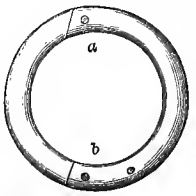


Fig. 416.—*Closed bull's ring.*
a Rivet joint.
b Lapped joint with 2 screws.

The ringing may be done more quickly and simply without the use of a hot iron, while improved rings are now made to save trouble in screwing.

Substitute for the Ring.—Although it is prudent to have a ring fixed permanently in the nose, many now prefer an instrument such as is shown in fig. 241, Divisional vol. iii., which can be tightened to grip the nose, as a person would grip it with his two fingers, and can be slackened again and removed at will. This indeed may and often is entirely substituted for the ring fixed through a hole in the nose; yet the ring through the hole is an additional safeguard.

Leading by the Ring.—The ring should not be used until the wound of the nose has had time to heal, though it is not uncommon for the ringing of a bull to be delayed until the time he is led to a show, when, the nose being still tender and sensitive, the poor animal is unnecessarily tortured. So alarmed do bulls become by this operation, that they hang back at the first attempt to lead them, and sometimes the leader thoughtlessly holds on by the rein-rope until the ring is torn through the nose. He should slacken the rope whenever the bull hangs back, as often and until he

learns to yield to the slightest motion of the rope.

Care in Leading.—The cattle-man in charge, and in whom the animal has confidence, should lead the bull for the first time. He should never *pull* the animal along after himself, but allow him to walk on while he walks at his side, or goes behind, with the rope in hand. While so following, to relieve the animal of the weight of the rope upon the nose, the man should throw the rope over the bull's back, and retain a hold of its end. Should the bull offer to step *backwards*, a gentle tap on the shank with a stick will check him; and should he run *forward*, a gentle pull of the rope will make him slacken his pace. On no account should the man struggle with the bull on the first occasion; on the contrary, he should soothe and pacify, and convince the bull that he will receive no hurt if he will but walk quietly along. A bull soon learns what is intended for him when he is properly dealt with; but if tormented merely that the man may show his power over him, it will be a long time ere he will learn to behave quietly when led, and in the meantime may become vicious.

Spring-hook.—The leading-rein is best fastened to a ring or holder by means of a spring-hook swivel, such as is shown in fig. 417. A movable part is jointed, and kept in its place by the spring behind it. When the hook is desired to be attached to the ring, the thumb presses on the movable part which yields, and allows the ring to be taken into the circular void of the hook. The rein-rope is spliced on the ring of the hook, which, turning upon a swivel, prevents the rope twisting. Such a hook can be attached and released from a bull's ring in much less time than any sort of tying.

Leading-stick.—A leading-stick, as well as a leading-rein, should always be used in handling adult bulls. The leading-stick is a strong pole, similar to the shaft of a hay-fork, with links and hook attached to one end for fixing into the ring in the bull's nose, or into the nose itself. By this stick the attendant has much better control of the bull than by a leading-rein alone. When two men are required to lead a bull, one holds the stick and the other the rein.

Grazing Bulls and Cows together.—A bull is never in a better position for serving cows than when grazing with them in the field. We believe it to be a fact, that a bull which is constantly amongst cows in a field rarely teases or abuses them, as would be done by one taken to them for the occasion out of his own house. But a bull can be left with the cows in the field only when he has to serve all the cows. When a bull is with cows, he is usually safe to approach, and quiet within the fence; but a bull is often troublesome by himself in a paddock or field, or even amongst oxen. He is constantly restless, often bellows, especially when he snuffs the wind from the direction of the cows. Hence he should either be confined to his hammel or byre, and supported on cut forage of some kind, or allowed to be with the cows he is to serve in a separate field from the rest.

Fig. 417.—*Swivelled spring-hook.*

a Movable part of hook.
d Joint of movable part.
c Swivel-joint of ring of hook.
b Spliced end of rope.

Summering Bulls in the House.—When it is necessary to confine a bull to a byre or loose-box during summer, he should have exercise once every day, and receive a full allowance of green food, such as grass and clover, and perhaps a pound or two of bruised oats and linseed-cake. With plenty of fresh grass he will need little else, unless he is hard worked in the service season, or has become low in condition. He will most likely relish a little dry hay amongst or alternately with the green succulent food. He should have access to water at least once daily, and be groomed once or twice a-week.

Temper of Confined Bulls.—When confined, bulls, like watch-dogs on the chain, dislike the approach of any one but their keeper; and even a keeper has been known to fall a victim to their caprice. Some bulls become then so

prone to mischief that they will attempt to run at every person when brought out of the house. Air and daylight together seem to have an intoxicating effect upon them.

Curbing a Savage Bull.—Several plans have been adopted for preventing a savage bull from doing harm, such as attaching a stick to his nose by a chain, or fixing a board in front of his eyes. A method which causes less inconvenience to the bull when not in the act of mischief, consists of an apparatus attached to the point of one of the horns, which, when the bull touches anything with this horn, pulls the string so tight in the nose, by means of a short chain, that he immediately desists.

The display of bad temper in bulls is more frequently occasioned by an improper upbringing in calf-hood than a natural propensity to vice. The training of young bulls should therefore be carefully attended to by the cattle-man, and not intrusted to boys or other inexperienced persons.

Number of Cows for a Bull.—Bulls can serve a large number of cows in a season, perhaps as many as 60, or even more. Where a bull is confined to the service of cows on the owner's farm, he has usually a smaller number; but it is a common practice to give the use of the bull to neighbours' cows at a certain charge per head.

SOILING.

The system of "soiling" might be humorously described as grazing cattle in the house! It consists of retaining the animals in the house,—the byre, hammel, or cattle-court,—and cutting and carting the green food to them, instead of allowing the animals to browse over the pastures and pick up the grasses for themselves.

Advantages of Soiling.—Several advantages are claimed for this system over the older and more simple and natural method of grazing. The chief of these are—(1) that a given extent of land will carry a heavier stocking of cattle; (2) that more actual food will be produced during the season; (3) that the quantity of food grown is more fully utilised; (4) that the animals thrive better, because they are protected from extremes of temperature, from the teasing of insects, and from undue exercise; and (5) that a greater quantity of manure is made upon the farm.

More Food Better Used.—It has been asserted by the more enthusiastic advocates of "soiling" that one acre "soiled" is equal to three acres pastured. This, we think, is overstating the case; yet it is unquestionable that by the frequent and systematic cutting of the grasses as they grow up, a greater weight of food will be grown during the season than when the pasture is cropped irregularly by stock in the ordinary method of grazing. Then with careful cutting and carting, every particle of the food is placed before the stock in a palatable condition, so that the material grown is more fully utilised than when it is trodden upon and unevenly eaten by cattle.

Animals Thriving Better.—Provided the animals are kept in comfortable, well-ventilated compartments, with plenty of fresh air, they will most likely give a better return for the food, in yield of milk or in accumulation of fat, than they would on the pastures exposed to sun and wind and to the teasing of insects. That young animals would develop bone and muscle more rapidly is very doubtful; but it has been abundantly proved that adult animals will accumulate fat more quickly in this confinement than upon pasture fields.

More Dung made.—The gain in this point is not so very great as many have contended. The heap of dung at the farm-steading will, of course, be largely augmented; but it has to be remembered that it has been augmented mainly at the expense of the pasture field, which would otherwise have been enriched by the droppings of the animals grazing upon it. The only gain in manure will arise from the treading down of the litter spread below the animals, and from the residue of any artificial food given in the house along with the cut grasses. It is doubtful, indeed, if any gain in the quantity and quality of the manure would be more than sufficient to repay the cost of returning the dung to the land.

By the earlier advocates of "soiling" it was argued that the droppings of the

cattle on pasture land were in great part lost to the soil by exposure. It is now known that this was a mistaken idea, and that there is perhaps no better way of utilising farmyard dung than spreading it upon grass land.

Disadvantages of "Soiling."—But while these important advantages may be urged in favour of "soiling," it has to be pointed out that there are certain disadvantages which must also be taken into account. "Soiling" is altogether a more artificial system than ordinary grazing. It necessitates the employment of more money per acre, not only in the larger head of stock, but also in providing the necessary house accommodation, and the considerably larger force of labour.

It will at once be obvious that the cost of labour is very much greater than with grazing. There is the cutting and carting of the grass, the tending of the cattle, the carting out and spreading of the dung, all of which must be regarded as extra work due to the system. The heavy labour bill is indeed the greatest disadvantage of the system as opposed to grazing.

Then, again, there is this further consideration, that substantial outlay may be incurred in providing food to the animals in the house before the grass is sufficiently grown to admit of being cut. Successional forage crops are grown for this purpose, as well as to supplement the grass at other times. All this involves additional outlay, employing more capital per acre.

Utility of the System.—Still there are many circumstances under which the system may — especially with fattening cattle and dairy cows—be pursued with excellent results. It is specially suitable for warm climates, where forage crops may be easily grown, and where cattle would be disturbed by the excessive heat in the open fields. Then, where the supply of water for fields is insufficient, house-feeding may be followed in preference to grazing.

It is not likely, however, that in the best grazing districts, or in the colder parts, it will ever displace the long-established system of summering stock on the open fields. Indeed, it has to be noted that with all the advantages claimed for it, the system of "soiling" cattle is not gaining ground in the British Isles.

HORSES IN SUMMER.

From the beginning of the spring work until the sowing of turnip-seed has been completed, the farm-horses have enjoyed no rest; and in the long hours of labour during a period from 15 to 18 weeks, they require a liberal allowance of good food to maintain their strength and condition. A little green food may be obtained for them before the sowing of the root crops is finished; but with this exception, the farm-horses, until the completion of the hard work of root-sowing, are fed just as they were fed while working hard in winter and spring.

Summer Leisure.—With the conclusion of the root-sowing comes the summer holiday for the horses. In some parts they spend this time of leisure in the cattle-courts and in others on the pasture fields.

Pasturing Work-horses.—On many farms, especially in Scotland, the rule is still to graze the horses. As soon as the warm weather of summer has fully set in, the horses lie out in a pasture field all night, and get cut grass between the yokings in the stable. When the first yoking is over, they are put on pasture until taken up for the afternoon yoking at 1 o'clock, which saves the trouble of cutting grass. Work-horses are liable to suffer much from chilly nights, cold often laying the foundation of diseases—such as rheumatism, costiveness, stiffness of the limbs. The aftermath is good pasture in the interval of work at noon, and the second cutting of clover may last for suppers until the time to betake to the stable altogether.

Soiling Horses.—Many farmers disapprove of pasturing farm-horses, and support them at the steading upon forage. Where there are hammels or courts which could be easily divided, we would adopt this plan at once, but we are doubtful of its advantage in a stable. The heat of a stable in summer—and the doors cannot be left open — with the evaporation of the increased issue of urine from the green food, cannot fail to vitiate the air. The cattle-courts are

more open; and if they can be divided so that each pair of horses may have a compartment to themselves, they will thrive admirably here. In the tillage districts of England this system of summering horses in the cattle-courts is extensively pursued. Many farmers, indeed, maintain that there is no better or cheaper method of keeping draught-horses in summer than in the courts, fed with green vetches or other similar succulent food, and dry hay, with perhaps a little bruised oats. Very often the grain is omitted. Still it is a good plan to give the horses a week or two of the fresh air in an open pasture field.

Pasturing Young Horses.—Young horses are put to pasture during the day as soon as they can obtain a bite. They should be brought at night into their hammels until the grass has passed through them; after which they should lie out all night in a field which offers them the protection of a shed or other shelter. Work-horses do not care for a shed on pasture, being too much occupied with eating during night to mind it. In rainy weather young horses should be kept in the hammel on cut grass, and not exposed to rain in the field overnight.

The farmer's saddle-horse should have grass in summer, as the best course of physic it can have. But it is more convenient to give it cut grass in a court or hammel than to send it to pasture, in which it may be with considerable difficulty caught when wanted.

Peculiarities of the Horse in Grazing.—It is surprising with what constancy a work-horse will eat at pasture. His stomach being small in proportion to the bulk of his body, the food requires to be well masticated before it is swallowed; and as long as that process is proceeded with while the grass is cropped, no large quantity can pass into the stomach at a time. The horse, like all herbivorous animals, grazes with a progressive motion onwards, and smells the grass before he crops it. His mobile lips seize and gather the stems and leaves of the grass, which the incisors in both jaws bite through with the assistance of a lateral twitch of the head. When grass is rank, he crops the upper part first; and when short, bites very close to the ground. Horses should not graze amongst sheep, as both bite close to the ground; and work-horses often injure sheep that come in their way, either by a sly kick or by seizing the wool with their teeth.

It is proverbial that horses do not graze well upon many of the very best bullock pastures. Horses often do better on rough pasture than on land which has been altered in its herbage by thorough drainage.

Horses Injured by Green Food.—Care must be exercised in beginning horses with green food every year. If allowed to gorge themselves too freely at the outset, serious illness may follow. Begin them sparingly with it, and if it should be wet or very succulent at any time during the season, it will be all the better to be accompanied or mixed with a little dry food such as hay.

DAIRY WORK.

The breeding, feeding, housing, and general management of cows and their live produce are fully discussed and described at convenient points in other sections of the work. Here we are to deal specially and at considerable length with the manipulation and utilisation of milk and its products.

The cow—the best friend to man of the entire animal creation — gives a bountiful yield of a delicious fluid, which, although universally familiar to the eye and welcome to the palate, is neither so well understood nor so skilfully manipulated and utilised as might be reasonably expected in the enlightenment of the present day. What, then, is this fluid? and what shall we do with it?

The notes in the following pages, intended to elucidate these two comprehensive questions, are not addressed in

any exclusive sense to those who are usually described as "dairy farmers"—those who make dairying their sole object, or the one great, all-absorbing feature in their farming. Our notes are designed for all who have milk to manipulate, in large or in small quantities. Whether it happen to be the milk of the crofter's one cow, the stinted produce of the breeding herd, or the fuller flow of the heavy milkers on the large dairy farm, the object all through should be the same—to turn the milk to the best possible account. Whether this will be as food for the residents on the farm, for calf-rearing, for sale as whole-milk, skim-milk, cream, butter, or cheese, will depend upon circumstances too numerous, involved, and variable to be discussed here with advantage. Whatever the destiny of the milk may be, it is important, in order to ensure the best possible results in its utilisation, that the operator shall be acquainted with the characteristics, the inherent properties, the weak points and the strong, of the commodity which he or she is handling. It is thus desirable that all farmers who keep cows, whether few or many, should make themselves familiar, not only with the characteristics and properties of milk, but also with the best methods of preparing it for the various purposes for which it may be employed.

The milking of cows has already been dealt with, page 24, Divisional vol. iii. Here we take up the milk as it comes from the cow-house to the *Dairy*.

THE DAIRY.

The special apartment designed as the dairy will, of course, be regulated in its capacity and equipment in accordance with the extent and nature of the dairying operations carried on upon the farm.

Upon mixed husbandry farms, where dairying is quite a subsidiary interest, or where, indeed, only as many cows are kept as will supply the wants of the farm itself, the dairy or "milk-house" is often merely a small compartment opening out of the kitchen or from the passage between the kitchen and the main dwelling-house.

Upon holdings where dairying bulks largely, the manipulation of the milk and its products requires a distinct building of considerable dimensions.

Be the extent of the dairy what it may, there are some important conditions which should be common to all. Leaving individual farmers to provide the dairy capacity required for their respective holdings, and also allowing them the fullest freedom in what may be called the embellishment of their dairy buildings, we would press for general adoption only such conditions and arrangements as are known to be essential for the successful handling of milk, butter, and cheese.

Some further reference will be made to the dairy when we come to speak of the construction of farm-buildings.

Situation of the Dairy.—In the first place, the milk compartment or dairy should be so situated as to be free from strong or unpleasant odours. Unless it is kept perfectly sweet, airy, and wholesome, successful dairying is out of the question.

Milk-room in Dwelling-house.—The "milk-house" in the body of the dwelling-house is therefore not a desirable arrangement. Odours from the kitchen, scullery, and pantry are liable to find access into this compartment, and play havoc with the milk, cream, and butter. If the dairying interests of the farm are too small to justify the erection of a separate dairy, make a point of having the milk compartment as far removed from the kitchen, scullery, and pantry as possible. Let it be in a cool, airy position, on the north side of the house if possible. Keep nothing in the milk compartment except milk—above all, nothing that gives off a strong or unwholesome smell.

A Medley in the Milk-room.—An arrangement by no means uncommon upon farms where little attention is given to dairying, is to have the milk-house and pantry combined in one compartment. Here, in close proximity, perhaps on one shelf, are milk, butter, cheese, old and new; cold meat from the table, dripping, fish, fresh and cured, and such odorous, savoury and unsavoury articles. A worse arrangement for the milk and butter could

not be conceived. Those who desire to have first-class, good-keeping dairy produce, must protect it from all such contaminations.

Separate Dairy.—A convenient position for the separate dairy is right back from the kitchen on the north side of the house. It is a good plan to have the kitchen and dairy connected by a covered passage, leading through a yard perhaps from 5 to 10 yards wide. It is desirable, of course, that the dairy shall be within easy access from the cow-house, yet not so close as to endanger the tainting of the milk with smells from the farmery or piggery.

Compartments in the Dairy.—With a small number of cows one compartment, perhaps about 12 feet by 14, may be sufficient for all the dairy work. In other cases there may be three or more compartments, a milk-room, churning-room, cheese-making room, with a cheese-store above. Two compartments for active work, and one in which to ripen cheeses, are usually considered sufficient.

Verandah.—It is a good plan to have a covered way or verandah along the south front of the dairy. This provides a shade from the noonday sun, and permits the dairy utensils being dried and aerated in rainy weather.

Finishings of the Dairy.—There is no need for elaborate or costly buildings for dairy work. They should be fairly roomy, not less than 10 feet in height, well ventilated and thoroughly dry, with a subdued rather than bright light. The ceiling should be lathed and plastered, and the flooring formed of some material which will be hard, proof against damp, and easily cleaned. Encaustic or enamelled tiles and polished pavement are often used, but there is nothing better than well-formed concrete with a smooth surface. The concrete floor is rounded at the edges and corners, and declining towards the door or other exit, so that with a hose-pipe and a good supply of water it can, with little trouble, be thoroughly flushed.

Dampness to be avoided.—Dampness is very injurious in the dairy. If the situation is of a damp nature, special precautions must be taken in constructing the dairy to ensure that its floor and walls shall be proof against damp.

Dairy Sink and Wash-tank.—There should be no sink or fixed water-tank within the milk-room or churning-room. A water-tap is convenient in both, but there should be no sink underneath the tap—at most only a slight indentation in the floor, which will carry off any stray water from the tap, and which may be easily cleaned with a sweep of the brush.

The washing-tank and sink for the cleaning of the dairy utensils will be either in a compartment by themselves or in the kitchen scullery. All underground drains should be provided with bell-traps. Many think it desirable to avoid underground drains. Surface drains are more easily kept clean.

Milk Shelves.—Shelves for holding milk-pans are usually fixed round the walls. The shelves should be formed of some non-absorbent material such as slate or flag-stone. Some prefer movable shelves, such as shown in fig. 428, to fixed shelving.

Temperature of the Dairy.—It is a matter of great importance to have the dairy kept cool, sweet, and fresh. Many consider an equable temperature so essential that they employ artificial means of regulating it—by hot-water pipes or a fire in winter, and by shading from the sun and flushing with cold water in summer.

One of the most perfect dairies we have ever known of was one in the State of New Jersey. Right in the centre of it there is a strong spring of delightfully pure water bubbling up from the rock, keeping the compartment almost equal in temperature all the year round.

To secure, as far as possible, a cool, even temperature, the dairy is sometimes sunk partly into the ground on a hillside, great care being given to the drainage; while walls and roofs are made double, with an air-space between. In summer the windows and doors are well shaded from the sun, and it is considered that a subdued is preferable to a bright light in the dairy. Specky or streaky butter is sometimes attributed to exposure to strong rays of light.

Precise limits need hardly be laid down as to the temperature of the dairy. The object to be aimed at is to have the atmospheric temperature of the milk-room lower than the temperature of the

milk itself. The tendency of milk to become contaminated by offensive odours is much increased when the surrounding temperature is warmer than the milk. Hot air coming into contact with colder milk becomes condensed and deposited upon the milk with all its impurities, whatever they may be. On the other hand warm milk placed in a colder room with pure cool dry air coming into contact with it, is more likely to be purified than contaminated. The cold air coming within the influence of the warm milk is expanded, and rising, may carry with it volatile impurities from the milk.

Professor Sheldon remarks that "milk that has been cooled by water or ice should not be exposed to an atmosphere 10° or 20° warmer: for it then becomes a facile condenser and absorbent. While the air is seldom pure enough not to injure milk that is 10° colder, it is seldom so impure as to vitiate milk that is 10° warmer." [1]

There is thus good reason for keeping the atmosphere of the milk-room cool, fresh, pure, and dry.

Importance of Temperature. — At every step in dairy work, no matter what branch of dairying may be pursued, the guidance of the thermometer must be constantly resorted to. Temperature is a controlling influence in all the operations of cream-raising, butter-making, milk-ripening, and cheese-making; and without due attention to this influence, success cannot be reckoned upon. Guess-work is quite unreliable, both as to the temperature of the room and of the commodities under manipulation. But there is a simple and efficient guide at hand—the common thermometer—which may be had specially adapted for dairy work at from 1s. to 3s. each. Glass or porcelain thermometers are required for inserting in and marking the temperature of milk, curd, &c. There should also be a wall-thermometer hanging in every compartment of the dairy, so that the temperature in each may be seen at a glance.

Dairy Utensils.

In regard to the kind of dairy appliances to use, it would be imprudent to dogmatise. In recent years vast ingenuity and enterprise have been employed in the bringing out of "new and improved" dairy appliances. We heartily acknowledge the benefits which have thus been conferred upon the dairy interest, for it has been established beyond question that many of these modern contrivances for use in the dairy are possessed of merits of the highest order.

Still it is not necessary that in order to ensure first-class dairy produce the dairy farmer should discard all his old appliances and adopt new ones. He will do so only as far as his experience, observation, and means seem to dictate and justify. This is pre-eminently one of those points as to which the dairy farmer may, with ample justice to the produce of his dairy, give considerable scope to his purse and his fancy.

Three important points to look for in all dairy appliances are simplicity and economy in working, facility in cleaning, and durability. Cheapness is, of course, also to be kept in view; and the greatest consideration of all is efficiency.

In the course of our detailed notes upon the various operations in the dairy, numerous appliances which are well thought of will be mentioned and illustrated.

Power for the Dairy.

In tolerably large dairies, where hand-power would be insufficient, a small steam-engine is very often employed. A vertical boiler and engine similar to that shown in fig. 49, page 135, vol. i., is well suited for this purpose. It should be so placed as to be useful for other farm-work as well, such as preparing cattle-foods. Horse and water power are also utilised for dairy work. A useful form of horse-gear for working dairy appliances is illustrated in fig. 132, Divisional vol. ii.

The steam-engine is best adapted for working the centrifugal separator.

MILK.

Milk, the most perfect of all foods, possesses characteristics which should be carefully studied by those who have to handle it and manufacture its products.

[1] *The Farm and Dairy*, 62.

Composition.

The composition of cows' milk varies greatly. The following may be taken as fairly representing (1) the analysis of an average sample of milk; and (2) the extremes in milk-analyses:—

	Average Analyses.	Extremes of Ingredients.
Water	87.40	81.00 to 91.00
Casein	3.30	3.00 " 4.10
Butter-fat	3.40	1.85 " 9.50
Milk-sugar	4.55	3.00 " 5.00
Albumen	0.60	0.30 " 1.20
Ash	0.75	0.70 " 0.80

The range of solid matter in milk is as great as from 9 to over 19 per cent. A good sample should contain at least 12 per cent. Different breeds vary greatly in the standard percentage of solids in their milk. Dutch cows would rank lowest, and Jersey cows highest, shorthorn cows being about the average. Even with the same cows there will be marked variations under good and bad treatment.

Butter-fat.—It will be observed from the figures given above that the greatest variation occurs in the butter-fat. In many samples of milk from Jersey cows, analysed at the London Dairy Show by Mr F. J. Lloyd, the percentage of total solids ranged from 13 to over 19 per cent, and this variation arose almost entirely in the butter-fat. The percentage of butter-fat ranged from about 4.10 to about 9.50 per cent, while total "solids other than fat" showed only very slight variation, at most considerably under 1 per cent. With the milk of shorthorn cows analysed on the same occasion, exactly similar results were obtained—that is, in regard to the variableness in the percentage of butter-fat, and the comparative fixity in that of the other solids. The total solids in the shorthorn milk ranged from 11 to 15 per cent, while the solids *other than butter-fat* did not vary more than about one-half per cent.

Composition of Milk from Different Breeds.—The following table, arranged by Professor M'Connell, gives the average daily yield of milk in pounds, with the fat and total solids in the milk, calculated out for each breed from the results of the trials with 432 cows at the London Dairy Shows in the ten years of 1880-89:—

	Breed.	Lb. of Milk.	Total Solids.	Fats.
119	Shorthorns	43.13	12.87	3.73
31	"	44.80	12.89	3.81
118	Jerseys	27.87	14.36	4.56
43	"	28.41	14.94	5.47
49	Guernseys	28.30	14.00	4.77
14	"	31.15	14.46	5.03
26	Crosses	39.12	12.91	3.69
3	"	51.86	12.28	3.23
7	Dutch	43.31	12.11	3.26
13	Ayrshires	34.26	13.43	4.15
2	Devons	30.12	14.34	4.90
3	Red Polls	43.10	12.72	3.60
1	Welsh	46.00	12.74	4.16
3	Kerries	23.50	14.22	4.40
432				

A comparison of the figures corroborates many points with which we are already familiar. Thus Shorthorn milk is not very rich in total solids or fat; Jerseys and Guernseys are very high in fat and total solids; Dutch very poor in fat and solids; and others medium. If the solids other than fat are worked out, it will be found that they vary only within a half per cent, not only within the limits of the breed, but between the averages of all; that is, they exist in the proportion of from 9 to 9½ per cent, no matter how much the "total" solids may differ, though, of course, the highest in one is also highest in the other. The exceptions to this only occur with the Dutch and Welsh in the above table, which fall below 9 per cent, where, however, the total solids are fair. Under the headings of Shorthorns, Jerseys, Guernseys, and Crosses, the averages of the last two years are given by themselves, showing that the general quality of all kinds as dairy animals is improving. There is an increase in every item right through, with the exception of the quality alone of the "Cross" milk—apparently due to an extra number of Dutch half-breds.[1]

It is thus established beyond question that by far the most variable ingredient in milk is fat. It is the commodity which is most within the control of the farmer, and which will be chiefly influenced by the feeding and general treatment of the cow. The fat, of course, is the ingredient from which the butter is derived.

Testing Percentage of Cream.—

[1] *Ag. Gazette*, 1889, 493.

This is not easily done with absolute accuracy. The ordinary *test-tube* — a glass tube with graduated lines at the top to mark the percentage of cream as it rises—is useful, but not quite reliable. The milk is put into this tube as it is drawn from the cow, and when the cream has risen, it shows on the graduated scale the percentage of the bulk of the cream. But the cream of different cows varies so much in the size of the butter-fat globules and therefore in specific gravity, that this test will not always show the entire and exact comparative quantities of butter-fat in samples of different milk. For mixed samples of milk from a number of cows it is fairly reliable, and is a ready means of testing much used in the new-milk trade. Every farmer should, for his own information, test the percentage of cream from his cows.

The *Lactocribe* is a most useful invention for ascertaining the exact amount of butter-fat in milk. It is worked similarly to the De Laval separator, and tests the milk by centrifugal force—making as many as twelve tests at one time. This is a very useful appliance in dairy factories or creameries, where cream is purchased from the farmers.

Fat-globules.—The butter-fat may be seen by the microscope to be in suspension in the milk in tiny globules. These globules vary in diameter in the milk of different breeds and different cows from $\frac{1}{2000}$ to $\frac{1}{20000}$ of an inch, and it has been estimated that there are over forty thousand millions of these fat-globules in a pint of milk containing 4 per cent of cream.

Casein. — This useful ingredient of milk, so important in the manufacture of cheese, is described by Professor Sheldon as existing in the milk in the form of an extremely attenuated jelly, owing to lavish absorption of water. There has been much discussion as to how far the percentage of casein can be influenced by the food given to the cow. Mr F. J. Lloyd says he is sure every chemist who has analysed milk will confirm his statement, that "we cannot by feeding perceptibly increase the casein contents of milk;" and he adds, that therefore the object in cheese-making should be to feed so as to increase the flow of milk and keep down the fat—that is unless a rich cheese is desired, when more albuminoids are given in the food to increase the fat. Some practical dairy farmers, however, contend that, by changes in feeding, they have been able to alter the casein contents of the milk.

Milk-sugar.—This is usually present in a larger quantity than any of the other solid ingredients. It is the most active agent in the decay of milk, as by the action of germs, *Bacterium lactis*, it is transformed into lactic acid, producing sour coagulated milk.

Albumen. — This nitrogenous substance is very similar to casein. Yet the two are so different that, while the rennet precipitates casein in the form of curd, the albumen passes off with the whey. It is this albumen and the sugar of milk that give to whey the feeding value it has been shown to possess (page 41, Divisional vol. iii.) This albumen coagulates on boiling the whey *after* the removal of the casein. It forms the skin which appears on boiled milk.

Weight and Specific Gravity.—A gallon of whole-milk weighs as near as might be from 10.25 to 10.35 lb. For simple calculation, it is a common practice to reckon 10 lb. of milk to the gallon. The specific gravity of whole-milk would vary from about 1.025 to 1.032, as compared with 1.000 for water as the standard. The higher the percentage of cream, the lower the specific gravity of the whole-milk. The specific gravity of cream itself is about .90.

Milk Statistics.—Taking the stock of cows in this country as a whole, the average yield of milk would probably be somewhere between 430 and 450 gallons of milk each per annum. Good average dairy cows of the heavier milking breeds —shorthorn, cross-bred, Ayrshire, Dutch, and red polled—should give from 700 to 900, some of them even 1000 gallons each in the twelve months. The produce of butter for a given quantity of milk varies greatly. The choicest butter cows, such as Channel Island cows, often give 1 lb. of butter from rather less than 2 gallons of milk, and average dairy cows in a butter dairy should give a pound of butter from 25 to 30 lb. of milk. Cheese-makers expect to get about 1 lb. of hard cheese, such as Cheddar, from

each gallon of milk; and a little less in Stiltons.

Weighing Milk.—It is very desirable that the product per day of every

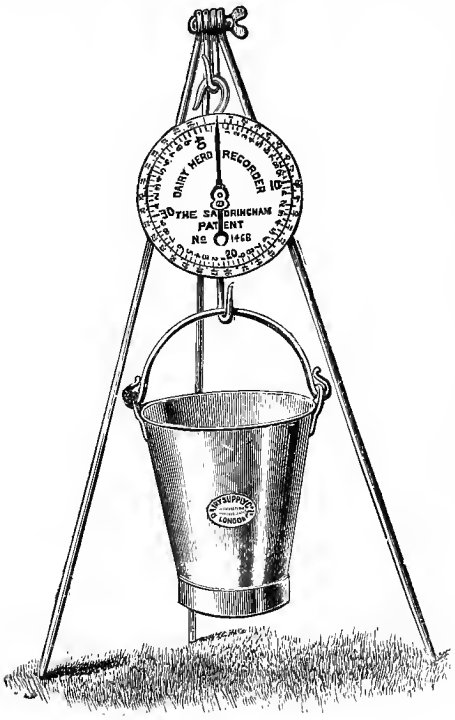


Fig. 418.—*Sandringham dairy herd recorder.*

cow in milk should be tested by weight at least once or twice every week. Useful information will thus be obained as to the return each individual cow is giving for the food she consumes. In the absence of precise facts as to the yield, unprofitable cows may be occasionally kept on longer than would otherwise be the case. A convenient appliance for weighing and measuring milk is represented in fig. 418 (Dairy Supply Co.) The dial shows the weight of the milk in pounds and ounces, and the measure or quantity in gallons and pints.

Purifying and Preserving Milk.

There are several processes by which milk may be to some extent purified and preserved sweet and wholesome for a time. As soon as milk is exposed to the atmosphere it is liable to absorb not only bad odours, but also living organisms (minute vegetable growths), which are continually floating about, and which accelerate the souring and decaying of milk. The action of these organisms is very much impaired by cooling the milk to about 50° or 55° Fahr., and this is frequently done as soon as the milk is taken to the dairy. It is also believed that by heating the milk to at least 170° the most if not all of these living germs are killed. In hot weather, therefore, when it is difficult, mainly on account of the activity of these organisms, to keep the milk sweet for any length of time, it is the custom in some dairies to heat the milk up to 170°, and then rapidly cool it to below 50°.

Heating and Cooling Milk.—There are numerous methods of heating and cooling milk. Where there are small quantities to deal with, it may be done by filling a tin can (such as shown in fig. 419) with hot or cold water as the case may be, and dipping it into the milk. Where there are large quantities to manipulate, other methods have to be adopted. In fig. 420 (Lawrence's patent refrigerator, for the illustration of which we have to thank Messrs Bradford & Co.) is shown a very efficient appliance for this purpose. A is the milk-receiver on top, and B the refrigerating part. This latter is formed of two thin corrugated sheets of tinned copper, placed side by side, with the flutings of the one sheet fitting into those of the other, the whole soldered to ends and made watertight. A thin stream of milk is allowed to trickle down over B and collected at C again, while cold water is led in between the sheets from D, and up and out at

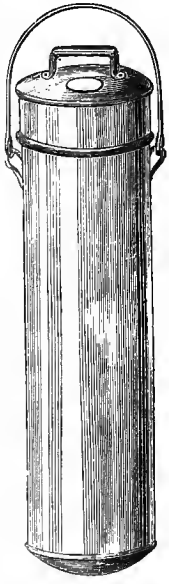


Fig. 419.—*Temperature can.*

exit E. By this means the milk is *suddenly* reduced from a temperature of about 90° Fahr. to nearly 50° Fahr., being *thoroughly aerated* at the same time. This cooling is the more efficaceous, because it is sudden, in nullifying the action of the souring germs, so that the milk remains sweet longer, while

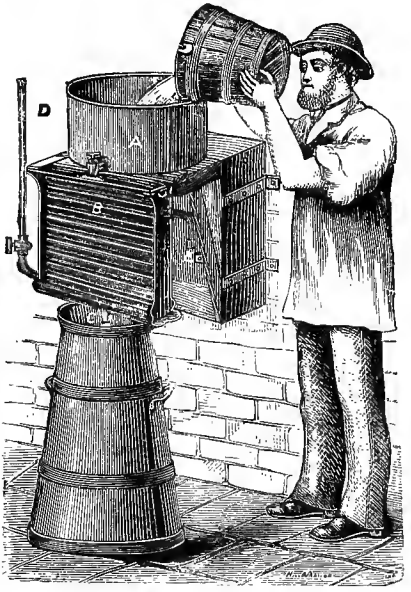


Fig. 420.—*Lawrence's refrigerator.*

noxious gases and flavours are removed by the aeration. By hot water (instead of cold) being run through between the sheets the milk may be raised in temperature.

A more elaborate arrangement of the same apparatus, designed to at the same operation scald and cool the milk, is represented in fig. 421 (Dairy Supply Co.) The milk from C runs over A, which is fitted with an arrangement for circulating boiling water internally, then flows over the refrigerator B, and becomes cooled and ready for use.

Milk in Sealed Bottles.—As a simple plan for keeping small quantities of milk sweet, Professor Long recommends that it should be sealed in bottles, and these submerged in boiling water for a few minutes. He adds that if this plan were universally adopted there would be no danger of attack from disease through the medium of milk.[1] Some indeed go the length of saying that all milk should be boiled before using.

Preserving Milk. — In Norway a system of preserving milk by sterilising it, and enclosing it in sealed tins, has been introduced with apparently some measure of success. The milk is taken direct from the cow, and, in the first place, is cooled down to ordinary temperature, about 50° or 60° Fahr., and then hermetically sealed up in tins. In this state it is exposed to a temperature of about 160°, and kept at this for one hour and three-quarters or thereabout, after which it is allowed to cool down to 100°, at which it remains for some time. It is then quickly heated up again to the former temperature of 160°. This alternate heating and cooling is repeated in the same manner several times, and then finally the temperature is raised to the boiling-point of water, or about 212°, after which it is cooled again to ordinary temperature, when it is found to be completely sterilised, not a trace of any organism or germ being left. It is therefore in a state in which it is said that it can be kept for an indefinite length of time without undergoing any change.

Boracic Acid as a Preservative.—It is well known that milk may be kept sweet for a longer time than usual by adding to it a little boracic acid or borax, which is in itself quite harmless in the milk.

Saltpetre in Milk. — Many farmers add to milk a little saltpetre dissolved in water. Professor Sheldon regards the use of saltpetre in moderation as a good thing. "In summer," he says, "it will help to preserve the milk, and in winter neutralise the bitter taste which is too commonly found in butter."

Condensed Milk. — The preparation of condensed milk is now quite an important industry. The process consists of evaporating the water of the milk and preserving the solids (mixed with sugar) in sealed tins. The nourishing elements in the milk may be thus preserved for any length of time, but the natural flavour has been to a large extent dissipated.

[1] *The Dairy Farm*, 7.

Destination of the Milk.

The treatment of the milk, from the very moment it leaves the cow-house, will to some extent vary in accordance with the purposes for which the milk is to be employed—whether (1) for consumption as milk upon the farm—as human food, and for calves, (2) for selling as whole-milk, (3) selling as cream and skim-milk, (4) butter-making, or (5) for cheese-making.

We do not intend to discuss here the relative advantages or disadvantages of

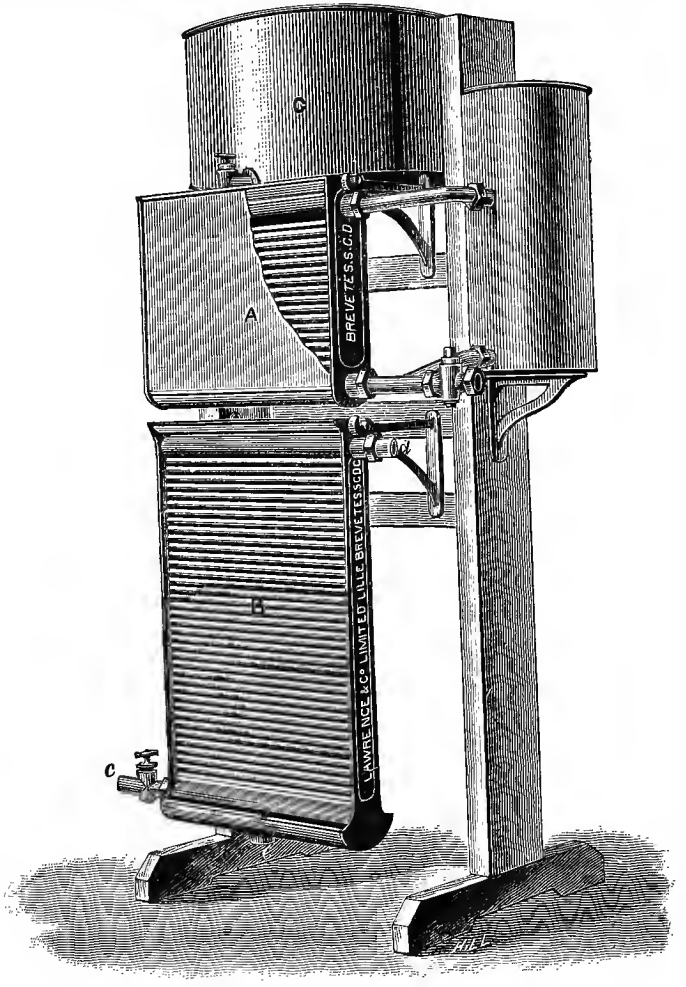


Fig. 421.—*Scalder and cooler.*

these various methods of utilising milk and its products. Circumstances as to supply and demand, and other conditions, may so vary in a comparatively short space of time as to completely upset former reasoning, and warrant farmers in altering their plans. Leaving farmers to decide for themselves, after due consideration of the circumstances of the particular time and locality, as to the method of utilisation that will afford them the best return for the milk, we devote our attention here solely to describing the details to be gone through

in each of the methods of utilisation pursued.

Consumption and Selling of Whole-milk.

When the milk is to be consumed on the farm, or sold as new milk, very little manipulation in the dairy is required. In the former case it may be measured out to the consumer just as it leaves the cow-house.

In the latter case, the milk should be run through the refrigerator as soon as it is taken to the dairy. In view of a journey by road or rail, the immediate cooling process, down to 50° or 55°, is very desirable. In fig. 420, the refrigerator is shown standing upon a railway milk-can, into which the milk runs as it leaves the refrigerator, and in which it is then removed to its destination.

Milk-selling Trade.—The selling of whole-milk for consumption in towns and villages has grown into a business of very large proportions. And as the taste for milk-food grows amongst townspeople—it is growing fast, and will surely enough continue to do so for many years—the milk-selling trade will go on increasing. In some cases the milk is conveyed from house to house by the farmer. The general custom, however, is to consign the milk and deliver it by road or rail to extensive milk-sellers, who contract with farmers for a certain supply during the year or season.

Cleaning Dairy Utensils.—With this system of disposal no other dairy work is involved, excepting, of course, the cleaning of the vessels used in conveying the milk. This latter is a most important matter, which should be attended to with the greatest care. Wash and scald the utensils thoroughly as soon as they come into the dairy empty. Upon no account leave any dairy utensil dirty over-night.

Milk for Calves.—The system of feeding whole and skim milk to calves is so fully dealt with in the chapter on calf-rearing, pp. 30-46, Divisional vol. iii., that no further reference need be made to the subject here.

CREAM-RAISING.

An important piece of dairy work is the separating of the cream from the milk. The manner in which this process is carried out has much to do with the success of dairying, more perhaps than is generally recognised.

Principles of Cream-raising.—The term cream-*raising*, which is extensively used, affords in itself an indication of the theory of the process of separating cream from milk. The factors involved are specific gravity and temperature. Cream is the lightest ingredient of milk, and therefore rises to the surface. The period of time which the cream requires to make its way to the surface depends largely upon the influence of temperature. Water is the largest element in milk, fat the chief ingredient of cream. Water is a better conductor of heat than fat—the former expanding with heat and contracting with cold rather more quickly than fat. Thus it happens that with a falling temperature, and the water in the milk cooling and contracting—increasing in specific gravity—more rapidly than the fat in the cream, the latter is more quickly forced to the surface. On the other hand, when the temperature of the mass is rising, the difference in specific gravity between the milk and cream becomes less, and collecting of the cream on the surface therefore slower.

The discovery of these facts has been of great service to dairy farmers, for it has enabled them to so manipulate the forces of nature as to raise the cream much more speedily than was attainable in former times.

In practice it is found that the sudden cooling of milk, as soon as it is drawn from the cow, retards the rising of the cream, while the setting of the milk, while it is warm, hastens the process.

Methods of Raising Cream.—At one time the setting of milk in shallow pans was almost universal in this country. Now, however, several other methods of raising cream are in use, and some of them have unquestionable advantages in their favour. The deep-pan system has many advocates, and so likewise have the centrifugal separator, the "Jersey creamer," the "Speedwell" cream-raiser, the "Dorset" system, and the Devonshire scalding system.

Shallow-pan System.

This system, the oldest of all, is still pursued by many successful farmers.

The theory of this plan is that by setting the warm milk in pans from 2 to 4 inches deep in a cool milk-room, the temperature of the milk will rapidly fall, and thus accelerate the rising of the cream. With a steady temperature of about 58° to 60° in the milk-room, this shallow setting gives satisfactory results, raising almost the whole of the cream within from 24 to 30 hours.

Airing Cream.—It is believed that the butter made from cream raised on these shallow pans is rendered superior to what it would otherwise be by the cream being brought freely into contact with a pure cool atmosphere in the process of rising. This was confirmed by the late Professor Arnold, who stated that "cream makes better butter if raised in cold air than in cold water. . . . The deeper milk is set, the less airing the cream gets while rising."

Disadvantages of the Shallow-pan System.—The chief disadvantages of this system are—(1) that it is liable to be rendered unsatisfactory by changes of temperature in the milk-room, (2) that it requires a great deal of shelving space for the setting of the milk, and (3) that it also involves much time and labour.

Temperature and Shallow Pans.—In the first place, if the temperature of the milk-room rise to unusual height, to anything over 60°, the milk is liable to become sour very rapidly, perhaps before all the cream has risen. Then by exposure to a temperature warmer than itself the cream is liable to absorb impurities. The importance of this latter point was enforced by the late Professor Arnold, who wrote: "While milk is standing for cream to rise, the purity of the cream, and consequently the fine flavour and keeping of the butter, will be injured if the surface of the cream is exposed freely to air much warmer than the cream. When the cream is colder than the surrounding air, it takes up moisture and impurities from the air. When the air is colder than the cream, it takes up moisture and whatever escapes from the cream. In the former case the cream purifies the surrounding air; in the latter the air helps to purify the cream."

The depth of setting, Professor Arnold added, "should vary with the temperature: the lower it is the deeper the milk may be set; the higher, the shallower it should be. Milk should never be set shallow in a low temperature nor deep in a high one."

Then if it should happen that the milk-room is unusually cold, under 50°, the milk may have to stand for 48 hours, and even then the whole of the cream may not have risen. The loss of a certain percentage of cream is not the only result of this slow rising of the cream. A great deal of shelving space must be provided for the milk, and this on a large dairy farm might involve considerable expense. Then the skim-milk will not keep so long sweet as if it had been separated sooner, while the labour in skimming and cleaning so many pans is also an item worthy of consideration.

Shallow Pans.—The pans in which milk is set in the shallow system consist of either stoneware, tinned iron, or wood. Common stoneware is the least durable of the materials employed, and is not now so extensively used as in former times. The harder and better finished varieties of stoneware are preferable.

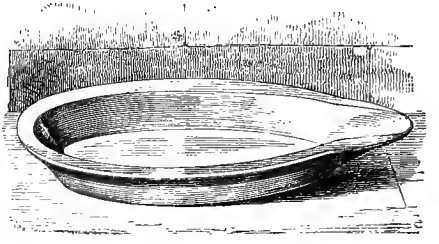


Fig. 422.—*White Wedgewood-ware milk-dish.*

Fig. 422 represents an excellent milk-pan made of white Wedgewood ware, oval in shape, 16 inches long and 3 inches deep inside measure. Milk-dishes of this material are wonderably durable, nice-looking, and easily kept clean.

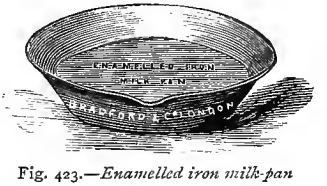


Fig. 423.—*Enamelled iron milk-pan*

The form of milk-pan now most

common, and perhaps on the whole the best, is shown in figs. 423 and 424. The former has a mouth to facilitate pouring.

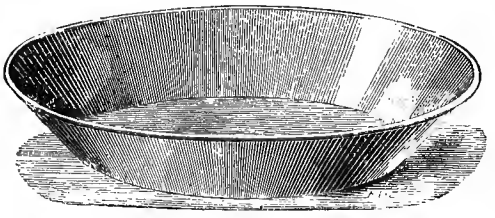


Fig. 424.—*Iron milk-pan.*

This pan is made of tinned iron, and similar tins are made of block tin stamped in one piece, or of iron with enamelled interior, and with or without a lip to pour out the milk by. This material admits of perfect cleanliness, while it is practically unbreakable.

Zinc Unsuitable.—Zinc or galvanising should never be used on dairy utensils, except perhaps on outside parts, where the milk or its products do not come into contact with the metal. Milk always tends to sour, the souring being due, as we have seen, to the formation of lactic acid from the milk-sugar by the fermentive action of a particular germ—the *Bacterium lactis*—which is always present. The acid so formed has a great affinity for zinc, forming zinc lactate, a substance which is highly poisonous, giving rise to nausea and vomiting.

Milk-sieve.—Another utensil required in a dairy is a milk-sieve, fig. 425, which consists of a bowl of tin-

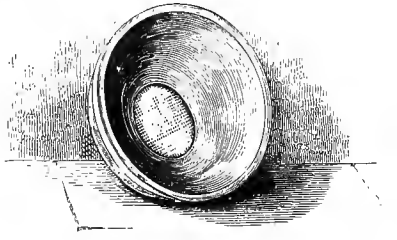


Fig. 425.—*Milk-sieve.*

ware, 9 inches in diameter, having an orifice covered with wire gauze in the bottom for the milk to pass through, and to detain the hairs that may have fallen into the milking-pails from the cows in the act of milking. The gauze is of brass wire, and, when kept bright, is safe enough; but silver wire is less likely to become corroded.

The straining of the milk through a sieve such as this, should in all cases be the very first operation after the milk is drawn from the cow. A very useful strainer is made for attaching to the side of the milk-pail.

Skimmer.—The creaming-dish, fig. 426 (Dairy Supply Co.), also of tin-ware, skims the cream off the milk. It is thin, circular, broad, and shallow, having on the near side a sharp edge to pass easily between the cream and milk, and a mouth is formed

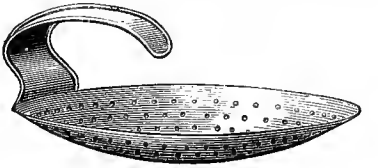


Fig. 426.—*Cream-skimmer.*

for pouring the cream into any vessel. At the bottom are a number of small holes for milk to pass through.

Cream-jar.—In small dairies the cream, until churned, is usually kept in a jar of stoneware, such as is shown in fig. 427, which is about 18 inches in height and 10 inches in diameter, with a movable top, having an opening in its centre, covered with muslin to keep out dust and let in air.

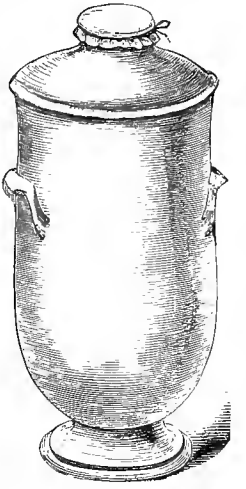


Fig. 427.—*Cream-jar.*

Shelves.—The shelves in dairies should be made of materials easily and quickly cleaned. Wooden shelves are easily cleaned, but are too porous and warm in summer.

Stone ones are better, but must be *polished*, otherwise they cannot be cleaned without being rubbed with sandstone. Marble or slate shelving is the best for coolness and cleanliness combined, and now neither is expensive.

Fig. 428.—*Movable milk-stand.*

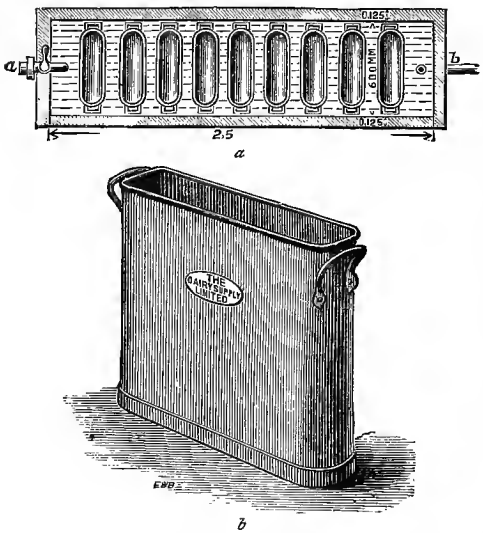


Fig. 429.—*Swartz system.*

a Trough with pans immersed in water. *b* Empty pan.

Movable Milk-stands. — In many dairies movable milk-stands have taken the place of fixed shelving. These stands are made of iron, and are in various shapes. Fig. 428 represents a very convenient stand, in which the discs revolve, so as to facilitate the turning of the pans for skimming.

Deep Setting.

The earliest departure from the old-fashioned shallow-pan system was the setting of the milk in deep pans.

The Swartz System.— In the Swartz system, represented in fig. 429, deep cans of milk are set in a trough filled with cold water, the water being kept continuously running through the trough. By these means the milk, set at blood-heat, or even warmed up higher, is rapidly reduced in temperature, and, as already explained (page 479), this falling temperature hastens the rising of the cream to the surface.

The Cooley System.—In the Cooley system, somewhat similar to, but in most respects an improvement upon the Swartz plan, a lid is fitted to each can on the principle of the diving-bell, so that the cold water is allowed to rise over the top. Slips of glass are fixed into the sides of the cans to show the depth of the cream, and taps are provided to run off the milk. Fig. 430 (for which we have to thank the Dairy Supply Co.) indicates the arrangement of the Cooley system.

Swartz and Cooley Systems Compared.—The main principle in the working of these two systems is the same — the accelerating of cream-raising by a falling temperature in the milk. The pans are about 20 inches deep, and in both the cream will have risen in about 12 hours. The main difference is in regard to the exposure and

enclosing of the cream and milk, as to which there is some difference of opinion.

Atmospheric Influence on Cream.—In the Swartz system, as we have seen, the pans are open at the top.

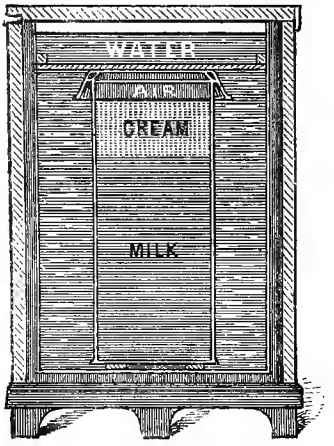


Fig. 430.—*Cooley system.*

Some regard this as an advantage, holding that the exposing of the cream to the air has an influence which improves the butter. Others, again, prefer the Cooley system, mainly for the very reason that in it the pans are closed and submerged, so that atmospheric impurities and changes are entirely prevented from coming into contact with the milk and cream. The condition of the atmosphere immediately around is the regulating influence. Exposure to a *pure*, cool atmosphere is beneficial to cream; contact with impure, hot air is distinctly the opposite. It is therefore claimed that the Cooley system is more to be relied upon in securing uniformly good results, in spite of impurities and changes in the atmosphere.

Ice used in Summer.—For these two systems, especially in the open Swartz trough, ice has to be employed in summer unless cold spring water is available.

Advantages of Deep Setting.—The setting of warm milk in deep pans in cold water economises time, labour, and space, and lessens the risk of injury to the cream from impurities and changes in the atmosphere.

Disadvantages of Deep Setting.—The appliances are more costly than for shallow setting, and the providing of the necessary supplies of water (and ice in summer) may be troublesome and costly. The improvement imparted to butter by the free exposure of the cream, when rising to a pure, cool atmosphere, cannot be so fully obtained in the deep as in the shallow pans.

Devonshire Scalding System.

The Devonshire system of raising cream by scalding is of long standing. Fig. 431 (Dairy Supply Co.) represents the appliances employed in this system.

Method of Working.—The milk is first set in the ordinary way in pans in a cool dairy (temperature about 60°), and at the end of about twelve hours the pans are placed on a stove, as shown in the figure, and the milk scalded to a temperature of about 180° —until the surface of the cream becomes wrinkled—when the pans are removed. The milk and cream are allowed to cool, when the cream is removed and put into crocks or jars, in which it becomes thick and clotted.

Merits of the Scalding System.—

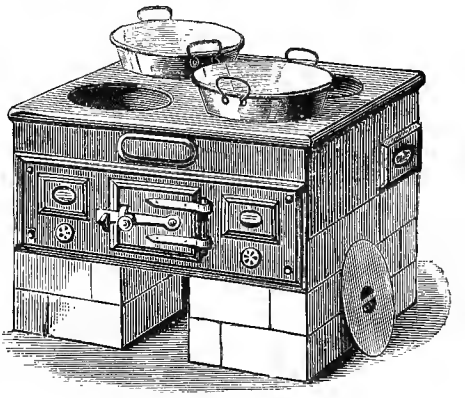


Fig. 431.—*Devonshire cream stove.*

This method of scalding raises more cream than would be obtained in the ordinary setting system. The butter is very easily made, and the scalding has the effect of purifying the cream and making it keep longer sweet.

Jersey Creamer.

One of the best known and most useful of modern contrivances for the speedy and effective separation of cream from milk is the Jersey creamer, shown in fig. 432. This provides an ingenious and admirable combination of the old shallow-

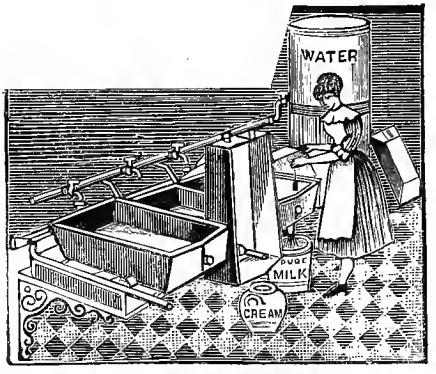


Fig. 432.—*Jersey creamer.*

pan system and the modern idea of exposing the milk to a cooling current of water. The pans have double sides, ends, and bottoms, with intervening spaces to permit the circulation of hot or cold water.

Method of Working.—The milk is put into the pans as soon as drawn from the cow. If it is not below 90° Fahr., it may be at once submitted to the cold current; but it is a speedier method to first run boiling water through the spaces around the pans, and thus raise the milk to about 110°. The hot water is then drawn off, and cold water run through until it is found that the milk has fallen to about the temperature of the water. The water should not be higher than 58° or 60°, nor lower than about 45°.

By this method of first heating the milk, the cream will rise in from 12 to 15 hours. Each pan is fitted with a tube, having at its lower end a very fine sieve, through which the skim-milk passes, leaving the cream in the pan, from which it is taken by removing the tube and stopper, or by simply tilting the pan forward on its hinges.

The lids are constructed to act as ventilators, and greatly assist the raising of the cream. They will allow all gases to escape; but at the same time prevent dust, flies, and every animal coming into contact with the milk.

Merits of the Jersey Creamer.—The Jersey creamer is admirably suited for average dairies, on a small or moderate scale. It is inexpensive, simple, and thoroughly efficient. The whole of the cream is obtained by this plan—perhaps from 10 to over 20 per cent more than by the ordinary method of setting and hand-skimming.

Speedwell Cream-raiser.

This is an ingenious and most valuable invention, which raises cream in a remarkably short time—in from 2 to 3 hours. Its construction is shown in fig. 433.

Method of Working.—The warm milk is put in to cover the series of cells, marked C in fig. 433. The whole pan is then set into a bath of water as cold as can be got, and milk is poured in till the surface of milk rises to the upper line of the slip of glass at A.

Method of Skimming.—When the cream has risen, it is removed by a skim-

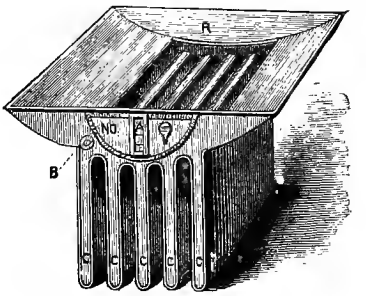


Fig. 433.—*Speedwell cream-raiser.*

mer, as shown in fig. 434. A careful hand will remove the whole of the cream at one course of the skimmer. When it is desired to leave some portion of the cream in the skim-milk, a little of the skim-milk is drawn off through the pipe at B before the skimming takes place.

Merits of the "Speedwell" System.—The rapid falling of the temperature of the milk is the stimulating influence in raising the cream here also. This ingenious dairy appliance is both simple and efficient, and is a wonderful econo-

miser of time in the raising process. It is made in different sizes, a small one of 1 gallon capacity being provided to suit the single-cow dairy. By the use of this appliance and the "Speedwell" crystal

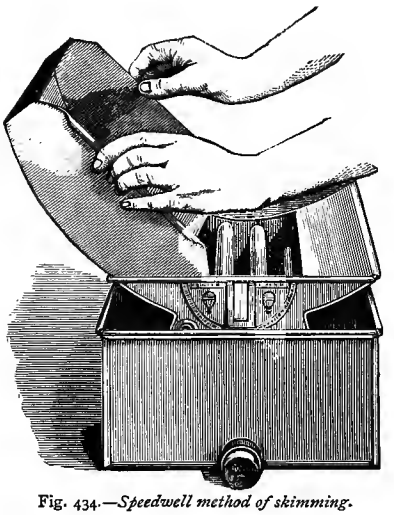


Fig. 434.—*Speedwell method of skimming.*

churn (fig. 444), cream may be consumed as butter from 3 to 4 or 5 hours after it leaves the cow.

Similar other Methods.

There are some other useful appliances for raising cream rapidly, all working on principles similar to those already described. The "Dorset" and the "Richmond" cream-raisers are both well spoken of, the former, in particular, being very largely used with excellent results.

Centrifugal Separator.

But the most remarkable and most useful of all the modern contrivances for separating cream from milk is unquestionably the "centrifugal separator." By the use of this admirable invention the cream and milk can be separated immediately upon leaving the cow.

Method of Working.—There are several patterns of this machine, all working upon similar principles. They were first manufactured on the Continent, but they are now made in this country by Mr John Gray, Stranraer, N.B., Messrs Freeth & Pocock, London, and others.

In fig. 435 the De Laval separator is shown at work. The new milk fresh from the cow is fed in at the top in a regulated quantity by the tube shown, and falling into a chamber which revolves with great velocity—from perhaps 2000 to 4000 revolutions per minute—the cream, because of its lighter weight than that of the rest of the milk, is thrown to the inner surface, and escapes by the higher of the two exit-tubes shown. The skim-milk, thrown to the outer part of the drum, passes out through the other tube. The separation of the

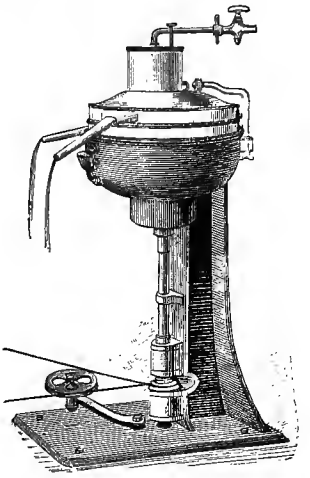


Fig. 435.—*De Laval separator.*

cream from the milk is practically perfect, and is performed with remarkable rapidity. The machine illustrated in fig. 435 will separate 150 gallons of milk per hour. By a form of the Danish separator made for very large dairies, over 200 gallons may be separated within an hour of the time the milk has been drawn from the cows.

The cream and milk coming from the separator are usually quite pure, dirt and other impurities being found adhering to the side of the bowl when the separator stops.

Power for Separators.—For the working of these larger separators, horse, water, or steam power is necessary. Regularity in speed is essential for perfect separation, and with horse-power this is difficult to obtain. A water tur-

bine-wheel is fairly suitable, but steam-power is most largely used. The De Laval separator is made with a steam turbine arrangement, with which only a steam-boiler is required to complete the means of separating.

The "Baby" Separator. — An ingenious form of the De Laval machine is the "Baby" separator, which was introduced into this country by the

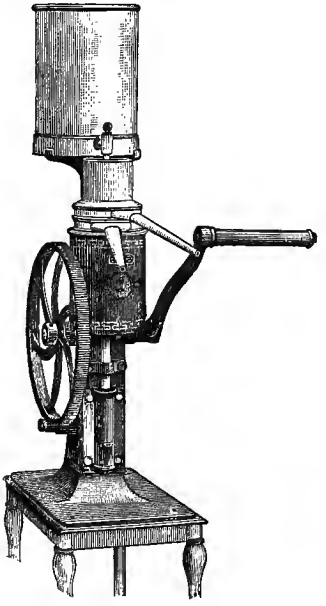


Fig. 436.—"*Baby*" *separator.*

Dairy Supply Co. This most useful little machine, which is shown in fig. 436, is adapted for hand-power. Driven steadily, by a strong girl or lad, it will separate from 12 to 20 gallons of milk in an hour. It is a valuable acquisition for small dairies.

Advantages of the Separator.— The advantages which may be derived from the use of the centrifugal separator are of great importance. In the first place the work of the dairy is facilitated and simplified, for the setting and skimming are done away with. The cream and skim-milk are obtained separately in a perfectly sweet and fresh condition, and therefore more suitable for marketing than if the slower system of setting and skimming had been followed. Then—and this is assuredly a consideration of great importance—the separation is so thorough, that, while practically no cream is left in the skim-milk, only the smallest percentage of casein is thrown off with the cream. The latter point is one of especial value, for it is well known that the presence of casein in butter tends to impair its quality and keeping properties.

One of the chief merits of the centrifugal separator therefore is, that by its use the maximum quantity and highest quality of butter may be obtained.

Selling Cream and Skim-milk.

Since the introduction of the centrifugal separator a large and growing trade has arisen in the selling of sweet cream and sweet skim-milk.

Separated Cream.—The inhabitants of towns and villages have a keen relish for sweet cream for tea, fruit, and puddings, and the separated cream is admirably fitted to supply this demand. The cream removed by the centrifugal separator is of course thinner—as indeed is the cream in all the rapid systems, whether by centrifugal force, or a falling temperature—than is the thick cream, which is obtained in the old method of setting and skimming, but it is much fresher, more wholesome, and will keep longer sweet.

"Speedwell" Cream.—The "Speedwell" cream-raiser is also likely to increase the use of fresh cream, as by it the cream can be obtained in a perfectly sweet and most palatable condition. Fig. 437 shows an excellent contrivance for cooling and aerating the cream, provi-

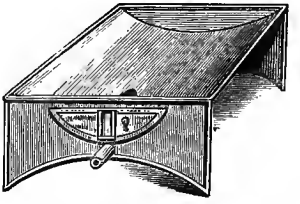


Fig. 437.—*Speedwell cream-cooler.*

sion being made in the bottom for drawing off skim-milk.

Preserving Cream.—One difficulty in the sweet cream trade is that of prevent-

ing the cream from getting sour. Various methods are tried with the view of overcoming this difficulty. The introduction of a little boracic acid into the cream has the effect of keeping it fresh longer than would otherwise be the case. Others adopt the more troublesome expedient of enclosing the cream in hermetically sealed tins of various sizes, containing quantities suitable for family and hotel use.

Devonshire Clotted Cream. — The system of scalding the whole-milk, which has been so long associated with the county of Devonshire, tends to strengthen the keeping properties of cream. The scalding destroys or impairs ferments in the whole-milk, and this followed by the cooling of the cream to a low temperature, perhaps 40° to 50°, tends to preserve the cream. This scalded cream becomes unusually thick and clotted, and is largely sold for family use in London and elsewhere. It is retailed in sealed tins, or small or large jars, which should be kept, in the shops, in suitable refrigerators. The system of scalding cream in Devonshire is described on page 483 of this volume.

Separated Milk.—The milk which is deprived of its cream by the centrifugal separator is no doubt poorer in a sense than milk skimmed in the old way, for, as a rule, by the latter system, less or more of the butter-fat is left in the milk. But if the separated milk loses in fat it gains in freshness. It is in a better condition for selling, and for consumption both by man and beast, than if it had sat perhaps till acidity had begun. And if it is desired to have the separated milk enriched with a little of the butter-fat, the separator can be set to provide for this.

But it should be remembered that, after all, the most nourishing and strength-giving ingredients of the milk, as it leaves the cow, remains in the milk after the cream has been removed. What it has lost in the butter-fat can be easily made up by other articles of food, and assuredly there is no more healthy or muscle-making food than plenty of fresh skim-milk. Happily its consumption amongst townspeople, to drink by itself, and for use in puddings and other food, is decidedly on the increase.

BUTTER-MAKING.

The next steps to the separating of the cream and milk are the ripening of the cream and the making of butter. In some parts of the country, as will be afterwards mentioned, the whole mass of milk and cream is churned, but the prevailing custom is to churn the cream only.

Ripening Cream.—No matter how the cream may be raised and removed from the milk, it should be "ripe" before being churned. This condition of "ripeness" in cream is rather indefinite. Widely prevailing opinions among high authorities are to the effect that the proper ripeness consists merely in the mellowing of the cream by exposing it for a few days to the oxygen of the air; that the cream should be churned before it becomes decidedly sour; that after it has become sour, further ripening deteriorates the cream; that butter from sour cream is not usually of the highest quality, because of the acidity in the cream injuring the delicate and volatile flavouring oils; that churning should take place the moment the slightest indication of acidity becomes apparent, indeed *just before* that, if this fine point—the approach of acidity—could be determined.

In practice it is very common to find the cream quite sour before being churned. The fact that sour cream needs less churning than sweet no doubt favours the practice of letting the cream become sour. At any rate, it is true that the main bulk of the butter of commerce, even those Continental brands most highly esteemed in the London market, is made from cream which is allowed to become less or more sour before being churned. The ripening is, indeed, the first stage in the souring process. As to the exact point in this process at which the cream should be transferred to the churn, experience will be one's best guide. Keeping in view the consideration as to the effect of over-ripening here mentioned, one should watch the results carefully, and regulate the practice so as to obtain the maximum production of the choicest butter.

Period of Ripening.—Cream ripens more quickly in summer than winter—a

high temperature exciting the activity of the organisms ("bacteria") in the cream, which give rise to fermentation. In a temperature at about 60° Fahr., cream ripens quickly, and may be ready for churning in from 12 to 20 hours. In a temperature as low as 45°, double that time may not be sufficient without assistance to the souring.

Cream which has been raised slowly in the open-pan system needs very little after ripening, and yet many leading dairymen consider that even this cream gives better butter and more of it by being kept mellowing in a cool temperature for a few days.

Cream which has been removed from the milk by the centrifugal separator or some of the other speedy systems, necessarily requires longer to ripen, unless some artificial souring is introduced. This fresh separated cream is usually exposed in a temperature of from 55° to 60°, with a muslin rag thrown over the mouth of the jar or vessel holding the cream, to keep out impurities and secure ventilation. Cream set to ripen should be stirred frequently, perhaps three times a-day.

Uniform Ripening of Cream.—It is very important that the mass of cream to be churned at any time should be as uniformly ripened as possible. This is most easily secured of course where the churning takes place daily or frequently. It can be fairly well obtained however by care in the mixing of the cream as it is removed from the milk. Each "creaming" should not have a separate vessel to itself unless it is to be churned by itself. The better plan is to have a cream-holder sufficiently large to hold all the cream to be churned at one time, and as each quantity of fresh cream is added, the whole should be thoroughly stirred, the stirring being perhaps repeated once or twice between the times of creaming.

In large dairies, where there is more cream to handle than could be conveniently kept in one vessel for each churning, the cream may at each creaming be evenly divided over any number of vessels.

This uniform ripening of all the cream in one churning is essential to obtain both the greatest quantity and the choicest quality of butter. The reason is not far to seek. Ripe cream passes into butter more quickly than fresh cream. Then with a quantity of ripe and a quantity of fresh cream in one churning the former would be over-churned before the whole of the butter-fat in the other would be transformed into butter. The result is usually a compromise, a little over-churning of the ripe cream and a slight under-churning of the fresh cream. Avoid the evils of this compromise by attending to the proper mixing and uniform ripening of the cream.

Artificial Ripening. — When it is desired to hasten the ripening of cream, this may be done by the addition of a small quantity of sour cream or buttermilk. The precise quantity of this sour matter to be added cannot be stated with safety for all cases, the lower the temperature the fresher the cream, and the milder the sour cream or buttermilk to be added the more will be required to make the ripening process go on rapidly. In Danish and Swedish dairies, where large quantities of excellent butter are made with admirable uniformity, a general practice is to add about 3 per cent of buttermilk to the cream, raise the cream to a temperature of about 63° Fahr., and churn after an interval of about 19 hours.

Salt in Cream.—In some instances salt is put into the cream before churning. Mr Thomas Nuttall, Beeby, Leicestershire (Lecturer on Dairying at the Royal College of Agriculture at Cirencester), puts in 1 lb. of salt to every 10 lb. of cream, and he considers that when the cream is ripened and treated in this way he gets better butter and a bigger yield —10 lb., where only 9 lb. would have been made in the usual way. The salt passes out in the buttermilk, which has to be sacrificed, as it is found useless even for pig-feeding. This practice, however, is quite exceptional, and is contrary to the experience of others.

Sweet-cream Butter.—For immediate consumption, butter made from sweet, imperfectly ripened cream, is by many preferred to butter from sour or well-ripened cream. But it does not keep so well as the latter, and the weight

of butter from a given quantity of sweet cream will be less by from 3 to 6 (perhaps even more) per cent than from the same quantity of sour cream.

Keeping Cream Sweet.—It has been stated that cream, which has been carefully ripened or mellowed for churning, is still sweet to the ordinary palate. That is, it is not appreciably sour. To preserve this sweetness in the cream while it is ripening, the cream should be kept in a cool place, and some add a little saltpetre or other preservative prepared for the purpose.

Times of Churning.—It is a common practice to churn only once a-week. Others think it preferable to churn twice, and many do so three or four times a-week, or even daily. In the majority of cases of churning once or twice a-week, the whole of the cream then in the dairy, excepting that taken off on the previous day and day of churning is well mixed together and churned. The fresh cream is usually held over till the next churning. The times of churning must of course be regulated by local circumstances, such as the quantity of cream to be handled and the demand for butter.

Temperature of Cream for Churning.—There is not a little difference of opinion, amongst both theoretical and practical butter-makers, as to what should be the temperature of cream when put into the churn. Fortunately, it would seem that upon this point some latitude may be allowed without seriously injuring the produce. Much, of course, depends upon the temperature of the churning-room. From 55° to 58° in summer, and from 58° to 63° in winter, are common ranges of temperature for the cream just on being put into the churn — 56° to 58° in summer, and 60° to 62° in winter, are perhaps most general. Some prefer to keep the dairy at the same temperature — about 58° to 60° — in summer and winter, and so churn the cream at the same temperature all the year round.

A high temperature hastens churning —the "coming" of the butter—but it tends to make the butter soft. A low temperature prolongs churning, with no appreciable benefit to the butter. Therefore seek for the "happy medium," which all teachers of dairying invest with much importance.

In Denmark the cream is usually churned at a slightly lower temperature than in this country—from 50° to 56°.

Churning Whole-milk.

The old-fashioned system of churning the entire milk as it comes from the cow, still holds a strong footing in several parts of the country, notably in the north of Ireland and south-west of Scotland.

Advantages.—The chief advantages claimed for the churning of the whole-milk are, that less dairy space and milk-setting appliances are required, that in certain districts more money can be obtained for the buttermilk than for skim-milk, and that more butter is obtained than where the milk and cream are separated, and only the latter churned. There is, no doubt, a saving in outlay for buildings and utensils, but the last advantage claimed is not now of universal or even general application.

In all probability a little more butter may be obtained by churning the whole-milk than when the cream is skimmed off by hand, as by this latter system some small portion of the butter-fat may be left in the skim-milk, and thus escape the action of the churn. But with the more effective methods of raising and removing cream, such as the "Jersey creamer" and the "centrifugal separator" (which practically separate the entire quantity of butter-fat in the milk), the churning of the whole-milk will not compare favourably, even in regard to weight of butter, while as to quality, it is as a rule inferior.

The improved contrivances for more speedily and effectually separating the cream from the milk have removed the strongest argument in favour of the churning of the whole-milk.

Disadvantages.—Amongst the reasons urged against the churning of the whole-milk are, that it involves a great deal of labour in churning such a large quantity of fluid, that the skim-milk is all in the form of very sour buttermilk, for which in many parts there is a poor demand, and that the butter is liable to be injured in quality by containing too much water. The butter made in this

way is more difficult to work, so as to effectually remove the water and the casein of the milk, with which it has been in close contact in the churn. Indeed, it is undeniable that it is more difficult to make first-class keeping butter in this way, than where only properly ripened cream is churned.

The buttermilk finds a ready sale in large towns for human food, but in the country districts the demand for this purpose is of course very limited. It is useful for feeding pigs, but not suitable for calves. There is this difficulty in profitably utilising large quantities of buttermilk.

Method.—In preparing the whole-milk for churning it is necessary that it should be well soured. If churned while sweet a good deal of the butter-fat may remain in the buttermilk. A little buttermilk is often poured in amongst the fresh whole-milk to hasten its souring, but this is not a good plan, as the buttermilk is liable to contain organisms that would be detrimental to the butter. If any artificial aid to ripening is necessary, it should be introduced in the form of a little whole-milk, which had been set aside to ripen for the purpose.

Continental Method.—By carefully regulating the temperature of the dairy and the depth of the milk in the butts, Continental dairymen, who churn the whole-milk, secure the proper degree of ripeness without introducing any ferment. For this purpose they keep the temperature of the milk-room somewhere between 45° and 59° Fahr. If the temperature is low, say between 45° and 50° Fahr., the milk should be filled into the butt to a depth of about 24 to 28 inches. If the temperature is higher the milk should be set shallower, so that when the maximum temperature of 59° Fahr. occurs the depth of the milk should not be more than from 12 to 16 inches.

The milk should be put into the butt just as it comes from the cow. No previous cooling is necessary, nor is it advantageous, as it retards the ripening too much. Should the butt not be big enough to hold an entire milking, the milk should be divided between two butts, but quite equally, so that the ripening may go on at the same pace in both, for unequally ripened milk makes bad butter. If the temperature of the room rises higher than 59° Fahr. the milk should be cooled, and if it should be too cool the milk must be heated, otherwise there will be imperfect ripening and consequent loss of butter. In about thirty-six hours the milk will likely have attained the proper degree of ripeness, and then, before being put into the churn, it is thoroughly mixed, so as to be rendered quite homogeneous.[1]

CHURNS.

It has been facetiously remarked that the dairy farmer may now have almost as much scope and freedom in selecting a churn as in choosing a wife! By this of course is meant, that, as with those who would be helpmates to the dairy farmer in all his affairs of life, there are very many patterns of churns, the majority of which are almost all equally well qualified to perform the important and delicate duties devolving upon them.

How many first-class churns there are in the market at the present day we do not venture to say; and to carry the above comparison a little further, it would perhaps be almost as unsafe and invidious in the one case as in the other to attempt to place in order of merit the claimants to the favour of the dairy farmer. With this additional remark we let the simile drop—that it is well for the dairy farmer that his wants are thus so admirably provided for.

But while we should not presume to draw up a list of the first-class churns in order of merit, we think it may be useful and interesting to illustrate and indicate the working of two or three of the well-known churns.

Types of Churns.—In general use throughout the country there are three types of churns less or more distinct: (1) those in which the fluid and the containing vessel with its agitators (if it has any) are in rotative motion; (2) those in which the containing vessel is at rest, and the agitators in rotative motion horizontally; and (3) those in which the containing vessel is at rest, and the agitators in rotative motion vertically.

[1] Dr A. P. Aitken on "Butter-making."

The old-fashioned *plunge-churn*, in which the agitator is worked by hand upwards and downwards in a stationary cylinder of cooper-work, is never seen now in a well-equipped dairy. It is still employed on some farms where dairying receives little attention, and where few dairy improvements have been introduced. It is heavier to work, and altogether inferior to the modern barrel

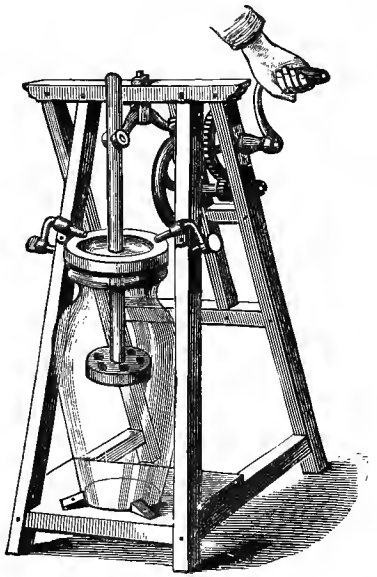


Fig. 438.—*The "ladies'" plunge-churn.*

churns. A modification of the plunge-churn, designed for easy working, is shown in fig. 438 (Dairy Supply Co.)

Barrel Churns.

The barrel churn in one form or other is now the most largely used. It may be formed in the actual shape of a barrel, hooped with iron, as shown in figs. 439 and 440, or in an octagonal box shape, as in fig. 441.

Ordinary Barrel with Beaters.—This popular churn, fig. 439 (Dairy Supply Co.), has fixed beaters, secured in an oblique direction and perforated, so as to produce the maximum amount of butter, and also be easily driven.

One drawback to this pattern is that the opening to admit of the removal of the butter and the cleaning of the churn is usually too small to be quite convenient.

End-over-end Churn.—This very efficient churn, shown in fig. 440 (John Gray, Stranraer), provides the great convenience of easy access into its interior.

Fig. 439.—*Barrel churn.*

One of the ends of the churn is made so that it may be entirely removed, and the freedom which is thus afforded the worker is of great importance, not only in the cleaning of the churn, but also in

Fig. 440 —*End-over-end churn.*

removing the butter. The axles are fixed so as to give the barrel an eccentric end-over-end motion.

Churns of this pattern have usually

been made to work without any agitators inside. In this case it is found that while the working is almost perfect when the churn is not more than about one-third to half-full of cream, it is difficult with a larger quantity of cream to obtain sufficient agitation throughout the entire mass to transform the whole of the butter-fat into butter.

Dashers or no Dashers.—Upon this particular point as to the advantages or disadvantages of internal "dashers," "beaters," or "agitators," there has been a good deal of discussion. It was argued, on the one hand, that the dashers injured the grain of the butter, and, on the other, that without agitators the full produce of butter could not be obtained. There is still difference of opinion, but, while it is conceded that the end-over-end eccentric churn without agitators makes excellent work when under half-full of cream, yet in general practice the dashers are more than holding their own. In the improved churns the dashers are designed so as to minimise or avoid injury to the butter.

Mr Somerville of Sorn states that he has found that any danger of having the butter-grains injured by the dashers is averted by using in the Holstein—an upright stationary barrel—a dasher which does not extend quite to the top of the churn. He mentions that the butter particles rise to the surface as they form, and thus do not come into contact with the dasher as it works below in the buttermilk, driving up any butter-fat not yet granulated. With dashers of this form he prefers a stationary to a revolving churn.

Diaphragm Churn.—The introduction of Bradford's "Diaphragm" into barrel churns has been attended with very satisfactory results. The "Diaphragm," which is seen hanging upon the churn, A in fig. 441, forms a sort of central division in the churn, removable for convenience, but stationary in the churn. This central division neutralises the centrifugal force, and ensures the equal and thorough agitation of the entire mass of fluid. Professor Sheldon speaks highly of the action of the "Diaphragm," remarking that, "I do not expect that any system of beaters or dashers or mixers will ever be invented to supersede the 'Diaphragm.'"

In this churn, also, the opening is not so large as could be desired. A better form of churn, in so far as concerns the opening (for convenience of manipulating the butter and cleaning the churn), is that shown in fig. 442—Bradford's improved "Victoria" end-over-end churn, known as the "Charlemont Diaphragm churn," to which a one-hand butter-worker is conveniently attached. The "Charlemont" churn is made so as to work with or without the Diaphragm;

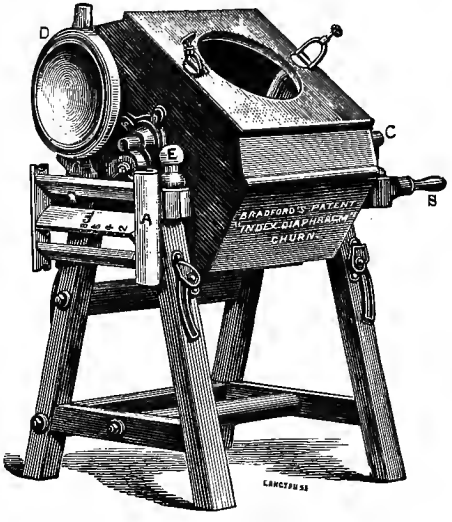


Fig. 441.—*The "Index Diaphragm" churn.*

A "Diaphragm" dash as placed when not in use. When slid into the churn groove, it indicates the quantity of cream in the churn.
B New patent spring handle.
C Rest for left hand while churning with the right hand.
D Lid, which is turned hollow to receive the butter from the churn.
E Plug (when not in use) in socket rest.

but the makers remark that the experience of a week or two always shows conclusively that it makes a better quality of butter with the Diaphragm.

Other Forms.

Box Churn.—Box churns, such as that shown in fig. 443 (Bradford & Co.), represent the second class referred to. They are provided with agitators, and are well suited for small dairies.

Holstein Churn.—The Holstein churn is an example of the third class of churn

mentioned. It is an upright barrel, with agitators which revolve horizontally while the churn is at rest. The Holstein churn is extensively employed in large

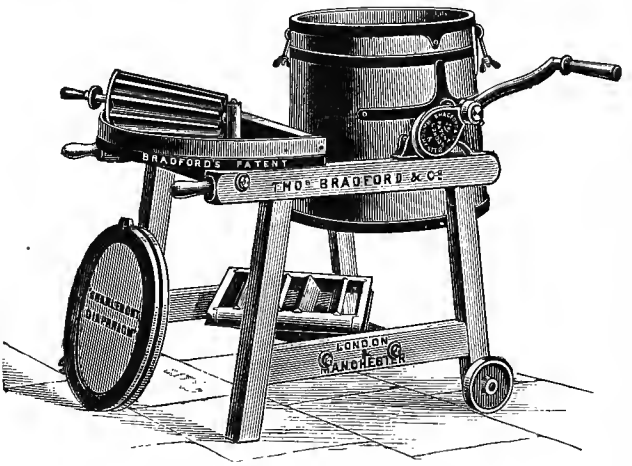


Fig. 442.—*Charlemont churn and butter-worker.*

factories and creameries, where a number of churns require to be driven separately from one shaft.

Streamlet Churn.—This churn, made of fire-clay enamelled, is extensively used for churning the whole-milk in the south-west of Scotland. It is usually made in large sizes, with dashers. It is rather

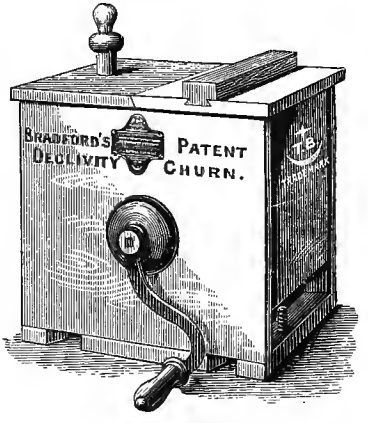


Fig. 443.—*Box churn.*

difficult to clean out, and for this purpose steaming is most effective.

"Speedwell" Crystal Churn.—This churn, shown in fig. 444, consists of one or more glass jars or cells, mounted in a revolving frame—a frame adapted for sitting upon a table, or a wooden frame as in the figure—which is easily transformed into a butter-working table. This churn is very convenient for churning small quantities of cream in private dairies. A form of this ingenious churn is made in which the glass jars have a double casing, so that the temperature of the cream may be raised, lowered, or kept stationary in the process of churning by the vacant space between the two casings being filled with hot or cold water. This is a valuable provision for churning in a high temperature.

Swing Churn.—There is still another sort of churn. It is in the form of a box or child's cot, and effects the churning by oscillation. It is used in a good many small dairies.

Important Features in a Churn.—While the farmer may exercise abundant freedom in the choice of the pattern of churn, there are a few important features which he should look for and insist upon. Amongst these are, that the churn should be easily cleaned, with no crevices wherein dirt may lodge and escape observation; that it should afford ample facility for removing the butter; that the churn may be easily ventilated; and that means should be provided for seeing the cream and ascertaining its temperature during churning. Light working as well as efficiency, should, of course, also have due consideration.

It is a good plan to have a small pane of glass in the churn through which to note the progress of the churning. And to permit the escape of gases evolved in the process of churning, there should be a ventilation valve in the lid of all churns.

Churning.

We now come to the details of churning. These require little explanation.

Preparing the Churn.—The preparation of the churn for the reception of the cream requires careful attention. It may be assumed that, after the previous churning, it had been thoroughly cleaned—first rinsed with cold water, then well scrubbed with boiling water, and again rinsed with cold. If it has not been in use for a few days, the churn may be scalded with hot water the day before churning. Some heat the churn with

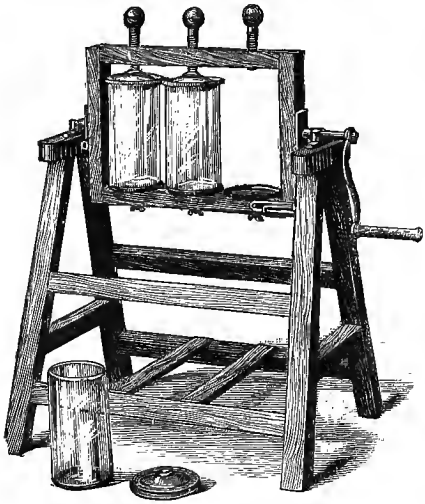


Fig. 444.—*Speedwell crystal churn.*

hot water just before putting in the cream. Others consider this a bad plan, and prefer to rinse out with water about the same temperature as the cream, or perhaps even two or three degrees lower than the cream. In cold weather the churn is frequently heated, and in hot weather cooled.

Upon the whole, perhaps the safest plan is to have the temperature of the churn just about the same as that of the cream to be churned, or a trifle below it, as the temperature of the cream rises a little, about 3° or 4°, with the friction in churning.

Some sprinkle a little salt in the churn before the cream is put into it, and others put salt into the water used in rinsing. The object of this is to counteract any taint that may possibly be present.

Accelerating Churning.—"It is a good practice," writes Professor Sheldon, "to pour acid buttermilk, say a pint to a gallon, into the churn along with the cream—buttermilk kept over from a previous churning. It has the effect of making the cream churn sooner, of producing more butter, and of hardening the butter, and clearing the colour of it. The finest sample of butter I have ever seen was produced in this way, in Ireland."[1] Others maintain that this admixture of buttermilk would be liable to injure the butter.

Straining Cream.—To prevent, as far as possible, impurities getting into the milk, the cream is run into the churn through a strainer, perhaps a coarse linen cloth, well known as cheese-cloth. This cloth is dipped in clean water, and held over the mouth of the churn while the cream is poured into it. The thickest of the clotted cream will be held back, and impurities, such as dust and flies, will be prevented from getting into the churn.

The straining-cloth is washed without soap, and kept sweet by exposure to air.

Speed of the Churn.—The churning has now begun. The speed at which the churn should be driven has been the subject of much difference of opinion. In practice there is also considerable variation. The rate should vary with different churns, but should begin slowly and end slowly. From 40 to 60 revolutions per minute are common after the first few minutes, until the butter appears in granules. Mr Thomas Nuttall, using Llewellyn's three-cornered churn without dashers, does not go beyond 35 revolutions per minute, driving even lower than that for a few minutes at the outset until the gas has evolved and escaped through the ventilator. Professor Sheldon considers that from 45 to 50 revolutions per minute should be the top speed with the ordinary barrel churn containing dashers; and that in hot weather seldom above 40, as the faster the speed the more the temperature of the cream will rise in churning, and in summer this should be avoided. With the Holstein vertical churn the rate

[1] *The Farm and the Dairy*, 76.

is often as high as 150 revolutions per minute after the first few minutes, and until the granules appear.

With very slow churning the butter is long in coming. With rapid churning the butter is liable to be soft and oily. With every individual churn, and in the varying circumstances of temperature and condition of the cream, the operator must exercise careful judgment as to the rate of speed in the churning.

Variation in Speed.—It is very important that for a few minutes at the outset, until the cream is broken and well mixed, the churning should be done slowly. After the first five minutes, until the butter-fat appears in the tiniest granules, there will be little danger, with a proper churn, of the fat-globules being injured by bruising, even although the rate of speed should be high. But the moment small granules are observed on the window of the churn, the rate should be slackened, and the churning completed at any easy speed.

With hand-worked churns it is easy to regulate the speed. Where horse or other power is employed to drive the churn, a difficulty has been encountered in varying the speed while the churning goes on. This difficulty has been overcome by the De Laval steam-turbine, and cone and friction pulleys are now arranged to give different rates of speed to the one churn.

Ventilation.—This must be carefully attended to in the first 8 or 10 minutes' churning. In the stirring of the cream at the outset, some gas is evolved, and the ventilator in the churn should be opened frequently during the first 10 minutes, to provide the desired ventilation.

Stop Churning.—The speed is lessened, we have seen, as soon as the butter-fat appears in tiny granules. This is a critical moment in butter-making. The old-fashioned method of plunging or grinding away with little variation, until the butter has collected in large lumps, is very injurious to the butter. The more tenderly it is manipulated while it is gathering, the better the butter.

As soon as the butter-granules attain the size of pin-heads—in no case larger than the grains of wheat—the churning should be stopped. The butter, indeed, is already formed. It has now to be separated from the buttermilk and collected into a solid mass of pure butter—a process quite distinct from churning.

Time Churning.—The churning will probably have occupied from 30 to 40 minutes. With less time, there is a liability to softness in the butter; with much more the flavour is apt to be injured. During the time of churning, the agitation will raise the temperature by perhaps 3° or 4°.

Sleepy Cream. — Occasionally the complaint is heard from the dairy that the "butter won't come," "the cream is sleeping." Most probably the cause will be that the cream is too cold. Test the temperature with the thermometer, and if it is below 55° in summer, or 58° in winter, raise it to slightly over these points by immersing a vessel filled with hot water (fig. 419).

But the temperature may be high enough and still the butter, or a portion of it, may refuse to come. In this case also, scalding the cream may be effective. If not, the use of a little churning powder, which it is well to have at hand, will most likely make the sleepy, frothy cream give up its butter. Dr Aitken considers a little bicarbonate of soda (baking soda) as efficacious as any butter-powder.

This difficulty is most liable to occur in the cold months of the year, and may be due to various causes besides cold cream, such as the feeding of the cows on unwholesome or over-dry food, a sickly cow, dirty milk-vessels, or to cream from cows that have been long constantly giving milk.

Butter-working.

The working of the butter is an important part of the operation.

Object of Working.—The object of working is the complete removal of the superfluous water or buttermilk, as the case may be, the working-in of the salt, and the consolidation of the butter into a solid mass. This should be done by pressure, not by rubbing, in order to avoid injuring the "grain" of the butter. If any portion of casein is left in the butter, it will speedily ferment and spoil the butter. Good keeping butter must

be free from casein; and, to obtain this, butter-makers cannot be too careful.

Process of Washing.—It is only while the butter-grains are small that the buttermilk can be entirely separated. When the churning is stopped, the plug-hole is opened, and nearly all the buttermilk allowed to run out through a sieve or piece of muslin cloth, which holds back the grains of butter. Clean cold water—in quantity about equal to the buttermilk withdrawn—is then poured into the churn, which is oscillated or turned gently a few times. The liquid is again strained out, and this process is repeated several times—just until the water comes away from the churn almost as clear as it went in. By this system every small grain of butter is separately exposed to the washing, and by no other method can the removal of the buttermilk be so thoroughly or simply effected. No more washing should be given than is really necessary to separate the buttermilk, for over-washing may injure the butter.

Salting.—There are three methods of salting—(1) putting the salt into the cream before churning; (2) by using brine, instead of pure water, to wash out the buttermilk; and (3) by mixing dry salt with the butter after it is washed. The first is a good plan for the butter, but it renders the buttermilk useless. Many eminent butter-makers continually use dry fine salt, as pure as can be obtained, worked into the butter after it has been washed. The brine system is perhaps most generally commended. It facilitates the thorough incorporation of the salt into the butter, and by it the degree of saltness in the butter may be easily controlled—added to or decreased. The brine is prepared by dissolving about 1 or 2 lb. of pure salt in a gallon of water, this being poured into the churn amongst the butter when the buttermilk has been removed. In other cases, the dry salt and cold water are put separately into the churn, which is then turned a few times to mix the commodities and dissolve the salt. With the mouth uncovered, the churn is then allowed to lie untouched from 10 minutes to 3 hours or even longer, according to degree of saltness required. Ten minutes will give very slight salting. If it is found that the salting has been too heavy, it may be lessened by gently washing the butter in pure cold water. By adding the dry salt when the butter is in the worker, the exact quantity is most easily given.

Professor Long points out that the same brine may be used over again three or four times, care being taken to add sufficient salt each time to balance the water which fresh-made butter always contains. There would probably be about half a gallon of water in every 10 lb. of butter, just after the buttermilk has been strained from it; and accordingly, for 50 lb. of butter he would use 6 gallons of cold water and 17 lb. of salt.[1]

Fig. 445.—*Butter-worker.*

The quantity of dry salt used for incorporating with the butter is rarely more

[1] *The Dairy Farm*, 22.

than 1 oz. per pound. This, indeed, is heavy salting, and should preserve the butter for many months. Even when it is to be used as fresh butter, a very little salt will improve the flavour of the butter.

Details of Working. — When the washing, and perhaps the salting, in the churn have been completed, the butter is removed to the butter-worker. In fig. 445 (Bradford & Co.) is represented a convenient form of butter-worker. The function of this article is to consolidate the butter, press out the water, and, if dry salt is to be introduced, incorporate this with the butter. The fluted roller alternately flattens and rolls up the butter, the backward and forward movement being continued until the objects of the working have been thoroughly attained. Yet the butter may be easily enough spoiled by over-working, so that good judgment and careful attention are necessary on the part of the operator. Fig. 442 represents a novel and useful combination — Bradford's Charlemont Diaphragm churn and a one-hand semicircular butter-worker. This combination is so arranged that by slanting the churn the butter will roll into the butter-worker.

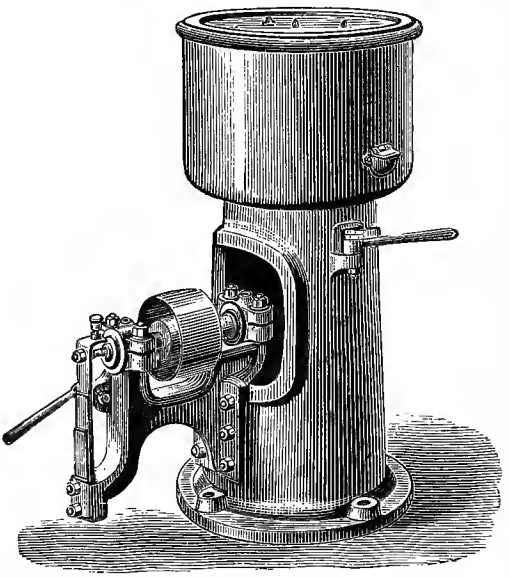


Fig. 446.—"*Délaiteuse*" *centrifugal butter-drier.*

Centrifugal Butter-drier.—This is an ingenious and most serviceable invention, in which centrifugal force is employed to remove superfluous moisture from the butter. It is named the "Normandy Délaiteuse" and is represented in fig. 446 (Dairy Supply Co.) The butter, after leaving the churn, is, while still in a granular state, placed—about 16 lb. at a time—in a canvas bag. This bag is then placed in a metal cylinder, perforated with holes, like a colander, which, from motion communicated by the horizontal spindle, is made to revolve rapidly—700 to 800 turns per minute. The buttermilk, and any other moisture the butter may contain, is driven off to the circumference, and thence through the holes into the outer case, whence it passes out by the pipe into a receptacle underneath, the butter remaining in a perfectly dry condition, in immediate readiness for being worked up into pats of whatever shape may be required. The whole operation only takes four minutes, and directly one lot of butter is dealt with another may be put in.

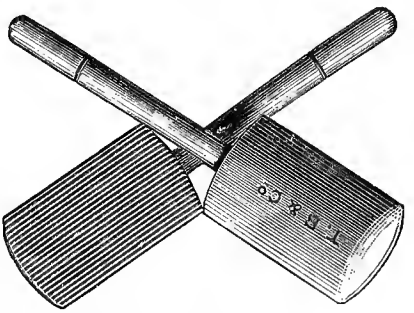


Fig. 447.—*Butter-beaters or boards.*

Butter Rolls and Pats. — When the butter is removed from the "Délaiteuse" it may be kneaded and compressed in the butter-worker, fig. 445, or by "Scotch hands" — very useful dairy appliances similar to the beaters, shown in fig. 447. These are usually made of box-wood, and are much used throughout the country in working butter into

rolls or pats for home use or sale. These rolls and pats should be made with care and good taste, not only for the sake of ornament on the table, but also for good effect in the market. Butter-boxes suitable for the conveyance of butter-rolls are shown in fig. 448. The rolls are wrapped into thin damp muslin cloths, and the boxes may be lined with white

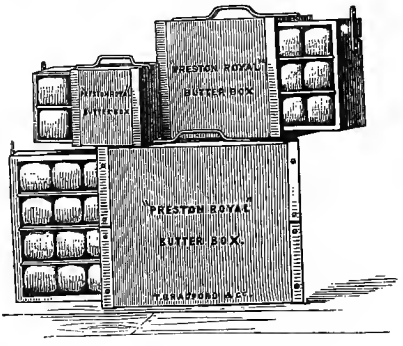


Fig. 448.—*Butter-boxes.*

paper. The boxes should be kept in a cool place until despatched to market, in which there should be as little delay as possible.

Hand-working Objectionable.—Many eminent authorities state emphatically that in all the process of working, butter should never once be touched by the bare hand. The temperature of the hand is usually so high as to have a tendency to make the butter soft, while there is also some risk of the flavour of the butter being slightly injured by contact with the hand. It is no doubt true that a great deal of first-class butter is worked by the bare hands of the operator, yet the safest plan, unquestionably, is to avoid this practice, and use some of the modern butter-workers which we have referred to and illustrated. With one of these and the deft use of the "Scotch hands" there is no need to let the bare hands touch the butter.

If in any case the bare hands are to come into contact with the butter, they should be first washed with warm water and oatmeal, and then rinsed in cold water, and this rinsing should be done frequently while the hand-working proceeds. A person with hot clammy hands is not suited for dairy work.

Packing into Crocks.—If the butter is to be kept for a considerable time, it is packed into crocks. And the packing process requires both skill and care. The object is to thoroughly exclude the air, and this will be effectually secured by packing the butter in shallow layers, not much over an inch in thickness. It is a good plan, after placing the first layer in the bottom of the crock, to line the sides with a similar layer as high up as it is intended to fill the vessel. Then proceed to press in one layer after another. Over the butter place a muslin cloth, and cover this with fine salt to the depth of about 1 inch.

To this covering some prefer to have about an inch deep or more of brine floating on the top of the butter. By this method, always taking care to keep the surface of the butter covered with brine, the writer has kept butter, which had been given merely a trace of salt in the working, quite fresh, from the beginning of October in the one year till into May of the following. Even at the very last the butter was perfectly free from any rancid or undesirable flavour, and was so slightly salt to taste as to almost pass for fresh recently made butter. But this butter was made by a skilled hand, who was careful to leave in it the least possible traces of casein, which is so destructive to the keeping properties of butter.

Prepared Preservatives. — Some useful preparations are now sold for preserving butter. But care should be taken to use only such as have been proved to be harmless and effective.

Fresh Butter.—If butter is properly made from well-ripened cream, well washed in the churn, and worked so as to have the surplus moisture removed, it may be kept sweet and fresh for several weeks without any salt whatever. Care should be taken to keep fresh butter in a cool temperature. In warm weather the farmer should have the butter made and conveyed to market at night or early in the morning; and in retail shops, refrigerators should be provided for holding the fresh butter in summer.

If the housekeeper find that her supply of fresh butter is likely to become rancid before being used, she will find it a good plan to pack the butter firmly into some fine glazed stoneware vessel and pour some strong brine over it.

Colouring Butter.—A rich golden colour is most esteemed in butter. When it is naturally pale or not sufficiently "gilt-edged" it is a common practice to colour it artificially. This may be done by introducing a little liquid annatto into the cream just before churning is commenced. Experience is the best guide as to the quantity required to give the required tint to the particular make of butter.

But artificial colouring is an objectionable practice, and where high-coloured butter is desired, the better plan is to have on the farm one or two cows known to produce high-coloured butter. Jersey and Guernsey cows are noted for this property, and one of these will most likely give sufficient "colouring" to the butter of ten or twelve other cows.

Butter Extractor.

At the Royal Show at Windsor, 1889, the Aylesbury Dairy Company exhibited the Swedish Cream Separator and Butter Extractor, "which constitutes a completely new departure in butter-making—and may, if it should prove successful in prolonged practice, possibly abolish both the churn and the dairymaid." So says the reporting judge in the *Journal of the Royal Agricultural Society* (Part ii., 1889), where he thus further refers to this very ingenious appliance:—

"The operation of churning, as is well known, consists in agitating cream, which is itself only a mass of separate fat-globules interfused with milk, until such globules cohere, and the freed fluid originally entangled among them passes away as 'buttermilk.'

"It recently occurred to Mr C. A. Johansson, a Swedish inventor, that the agitation necessary to bring about this result might be given in the centrifuge itself, and while the separation of milk and cream was going on. With this end in view, he furnished the milk-drum with a cover, from the centre of which there hangs a vertical axle, which becomes concentric with, or slightly eccentric to, the centrifuge, by turning a graduated handle this way or that.

"A circular cage, composed of half-a-dozen thin vertical wires, is supported from, and free to turn around, the axle in question: while the milk-drum is provided with a second and smaller annular chamber, which, as the spinning proceeds, becomes entirely filled with the cream-ring, whose internal diameter, determined by the position of escape-ducts in the floor of this chamber, is very slightly greater than that of the 'agitating cage.'

"The latter is made to touch the cream-ring at one point in its circumference by turning the handle governing the eccentric spindle, and can thus be more or less deeply immersed in the cream. The cage is set revolving by contact with the cream-ring, just as a pinion is turned by a wheel; but it fails to attain quite the same speed as its driver, on account of its own inertia. Its wires, which pass vertically down from top to bottom of the cream-ring, thus create a considerable agitation among the superficial layer of fat-globules, and, it is claimed, convert them into butter, which, as milk flows into the centrifuge, passes away continuously through ducts provided for that purpose in the floor of the inner cream-chamber.

"A greater or less agitation follows on setting the cage more or less eccentrically with the milk-drum, and creams of different character or density are dealt with in this way.

"It was arranged that this machine should be tried on Wednesday, June 26. Two hundred pounds of milk were weighed out and all put together, and carefully mixed in a can and samples taken. I should state that the inventor wished to reduce the milk to 60°, but time would not permit, and the milk used for the trial was 65°.

	h.	m.
The machine was started at .	5	23
Skim-milk came at	5	30
Commenced churning at . . .	5	32½
Butter came at	5	33½
Finished at . . .	5	47

On completion—

	lb.
Weight of skim-milk was . . .	183¾
" butter and buttermilk was .	16¼
" butter made up . . .	7

Dr Voelcker certified as follows:—

Original milk	Total solids	12.41	per cent
	" fat.	3.45	"
Skim-milk	Butter-fat	0.30	"
	Solids (total)	10.11	"

"The butter was lumpy rather than granular, somewhat soft and pale-coloured, and would not have passed muster with the butter made by Miss Maidment [winner of the Queen's gold medal for butter-making] in the dairy, though it tasted better than a great deal of the butter sold throughout the country."

The judges awarded a silver medal for the Extractor, although they were not prepared to say that its complete practical success had yet been demonstrated.

CHEESE-MAKING.

The systems of cheese-making pursued in this country are numerous. It is a more intricate process than butter-making, affording scope for the exercise of greater skill in manipulation, and of more ingenuity in producing differences in the manufactured article.

In making the hard cheeses of this country the entire milk as it comes from the cow is dealt with. In making Stilton cheeses a little extra cream is usually, and ought always to be added. The cheese-maker has thus a bulky article to handle, and one which requires to be treated with the utmost skill and care if uniformly good results are to be obtained.

Apartments for Cheese-making.—In well-equipped dairies there are at least three separate compartments for cheese-making—(1) the milk-room, (2) the curd and pressing room, and (3) the drying-room. In Stilton dairies there are generally three but sometimes four compartments. A convenient arrangement is to have the store over the other compartments, or perhaps over the curd or cheese-making room only. Some prefer to have the store in a cool dimly lighted ground-floor room.

An important point is to have the compartments as much as possible protected from variations in temperature,—so arranged that the temperature may be artificially controlled independently of the season of the year.

And, as in butter-making, the apartments and vessels must be kept perfectly clean, sweet, and fresh. Bad smells and impurities in the milk are fatal to successful cheese-making.

Utensils.—The utensils required in cheese-making are numerous, but they need not be costly. They usually consist of a milk vat or tub, strainers, curd-knives, curd-mill, curd-shovel, curd-rake, cheese moulds or hoops, cheese racks or shelves, cheese-presses, pails, and pans, &c.

Vat.—The vessel in which the milk is collected to be coagulated by rennet is

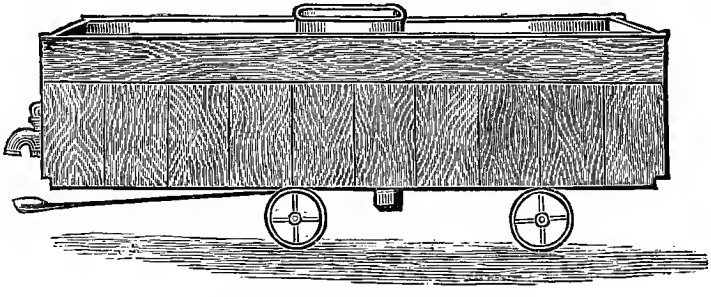


Fig. 449.—*Milk-vat.*

commonly called a vat or tub. It may be oblong, as shown in fig. 449, about 20 inches deep, and 30 to 32 inches wide, and mounted on 3 or 4 wheels so as to be easily moved about, and from one apartment to another. The vat is made of many sizes to suit different dairies. This is the most modern vat. It has a double casing, so as to admit between the two cases cold water for cooling and hot water for heating the milk and curd. The inner case should be made

of the best tinned steel; and the vat is provided, as shown, with brass taps, as well as with draining cylinder, siphons, covers, and draining racks, on which last the curd is placed to strain.

Circular Cheese-tub.—Formerly the milk-vat was in the form of a circular tub. In very small dairies these tubs may still be convenient for the handling of small quantities of curd. Indeed

Fig. 450.—*Curd-mill.*

there are not a few noted cheese-makers who still prefer the circular tub. With either the round or oblong vat first-class cheese may be made; but the modern oblong vat, with the double casing for heating or cooling the contents, is unquestionably the most convenient.

Heating Curd.—In the modern vat with double casing the curd may be heated as desired by circulating steam or hot water between the two cases, which are usually about 2 inches apart. The perfect control which this gives over the temperature of the contents of the vat is regarded by most modern cheese-makers as of the very first importance. There are some who contend that this system is liable to injure the cheese by over-cooking the portions of curd which come into contact with the hot sides of the vat. This risk may be avoided by raising the heat slowly. In the round tubs the curd is heated by withdrawing a quantity of the whey, scalding it to a high temperature, and pouring it over the curd. This has to be frequently repeated, and is a troublesome process.

Curd-mill.—The frame of the curd-mill, fig. 450 (Dairy Supply Co.), is usually made of wood, consisting of two bars supported on four legs. On the top is fastened the hopper with movable pins and hinges, and at the bottom of this runs an iron axle armed with pins or teeth fixed on it spirally, and below this again a metal grating. A handle drives the toothed axle, and the teeth pass through the bars of the grating, so that slices of "green" curd when put into the hopper are cut and broken through the grating, and fall into a receiver below. The metal working parts are tinned over; and the wood must be

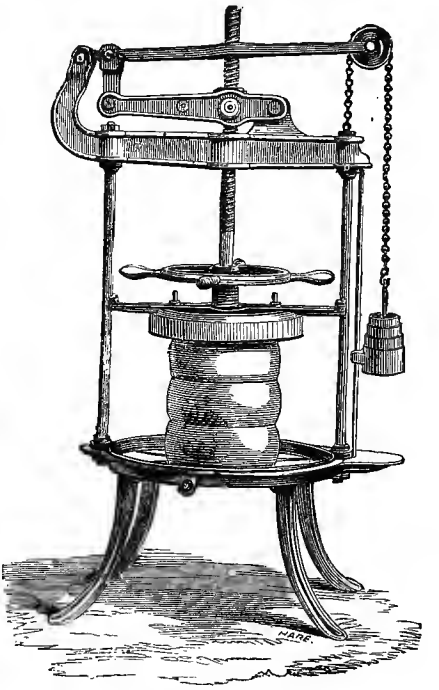


Fig. 451.—*Single cheese-press.*

of some close-grained variety, and well seasoned, while the framework is sometimes made of iron.

Presses.—Of the cheese-press the varieties are numerous. Those most in use may be classed under two kinds,

with and without levers. Of the lever-press the varieties are most numerous, passing from the single lever, through the various combinations of simple levers, to the more elaborate one of the rack and levers. An essential characteristic of each is that the load, when left to itself, has the power to descend after the cheese which is pressed, and which sinks as the whey from the curd is expelled. None but such should be used in any dairy.

Convenient lever-presses are shown in fig. 451 (Dairy Supply Co.) and fig. 452 (John Gray).

Shelves.—These are arranged in various forms. The most convenient are the self-turning shelves, those made so that two or three shelves turn round on an axle with their contents of cheese.

Rennet. — Rennet, the agent employed to coagulate milk, is an extract from the mucous membrane of the fourth stomach of the calf. It is indeed the agent which digests the food of the calf, and it is remarkable that no perfect

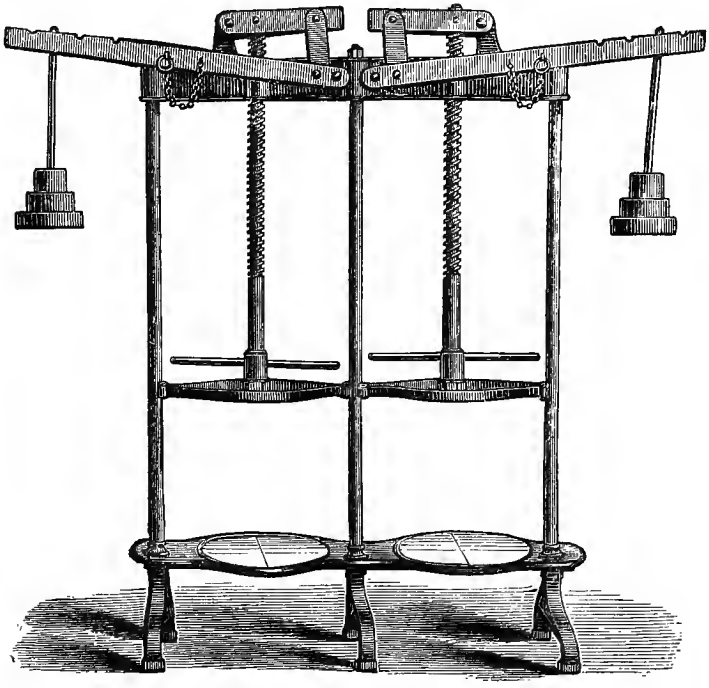


Fig. 452.—*Double cheese-press.*

substitute has yet been found for the natural calf-rennet in cheese-making. The rennet is prepared in the following manner: Good clean *vells* or stomachs are selected and put into salt brine—which has been made strong enough to float an egg—at the rate of four to every gallon. To this is added half an ounce of saltpetre and half a lemon sliced. The whole is put into a covered jar, and allowed to soak for a month, when it will be ready for use. Half a pint of this will, with the help of a little sour whey, coagulate 100 gallons in an hour. Where cheese are intended to ripen quickly, however, more must be used. and it is customary to put in nearly double this quantity.

In some cases the hard dried skin or *vell* of the calf's stomach prepared in brine is cut in small pieces, macerated in water, and the liquid put into the milk. This, however, is not a good plan, for it is difficult in this way to regulate the amount of rennet applied.

Testing Rennet. — The proper use

of rennet is a critical point in cheese-making. Mr Joseph Rigby says—"It is most important to have it of uniform strength, to know what that strength is, and to use the right quantity. The most practical and reliable way of ascertaining the strength is to take a drachm of the liquid, or a fixed portion of the powder, and mix it with five gallons of milk at the temperature it is usual to make the whole of the milk when putting together for cheese, and to notice how long it is before it begins to thicken, as the curding power of the milk often differs. If this occurs in twenty or twenty-five minutes, the right proportions will have been found. If it takes a longer time, more rennet is required; if a shorter time, a less quantity should be fixed upon. The exact quantity can only be fixed upon by repeated careful tests in individual dairies. Too much rennet causes the curd to become dry and brittle; too little leaves it soft and spongy."[1]

The more general plan now is to use some of the prepared extracts of rennet, which are sold at moderate prices, of uniform strength, and with useful directions as to application.

Action of Rennet.—The rennet acts on the milk by coagulating the casein, in which the butter-fat thereby becomes imprisoned. Both are thus preserved for use as food. Rennet also co-operates with acidity in softening the fibre of the curd, assimilating moisture, and in ripening the cheese, but its entire action is still imperfectly understood.

Acidity.—A much-disputed question in cheese-making is the amount of acidity which should be developed in the milk and curd during the various stages of the process. In the Cheddar system a certain amount of acidity is regarded as absolutely essential to bring out the full nutty flavour which is so much desired in Cheddar cheese; and unless the milk were allowed to ripen sufficiently before the rennet is added to develop in the curd the necessary degree of acidity in from five to seven hours, the curd would be liable to be injured by having to lie too long in the whey—engendering, perhaps, a bitter flavour instead of the rich flavour characteristic of the well-made article.

Mr Nuttall, Leicestershire, the well-known Stilton maker, condemns the ripening of the milk before the addition of the rennet, maintaining that it should be coagulated while it is still warm with the animal heat. But while this system may be advisable for Stilton making, it is not approved of in making Cheddar and other hard cheeses.

No doubt too much acidity is injurious to the cheese. It will spoil the texture and make the flavour too sharp. But without a certain amount of acidity developed at one stage or other the cheese will be weak-flavoured, perhaps even insipid. In poor milk less acidity should be developed than in rich milk. For this reason the acidity is kept more moderate in spring than in summer and early autumn.

Acidity, Ripening, and Keeping.—Acidity has much to do with both the rate of ripening and the keeping properties of cheese. If a considerable amount of acidity has been developed, the cheese will ripen quickly, but will not keep long. With little acidity the cheese ripens slowly, but has good keeping properties. Too much acidity will make the cheese dry and "crummy," and prevent mellow ripening.

Artificial Souring of Milk.—The plan, once common, of souring milk by mixing with it a little sour whey before putting in the rennet, has lost favour with many cheese-makers. Mr Drummond, instructor at the Kilmarnock Dairy Institute (one of the specialists brought from Canada to teach the improved methods of Cheddar cheese-making in the south-west of Scotland), says he has no doubt that in the old system whey was often added to the milk when the latter was already acid enough, thus resulting in a spoiled cheese. He considers a certain degree of acidity or ripeness in the milk as quite essential before adding the rennet, but this acidity he prefers to develop naturally in the milk by controlling its temperature—by having the evening's milk cooled so that enough heat will be left in it to develop by morning the slight acidity required. The warmer the milk the more rapidly it becomes sour. He generally found that

[1] *Jour. Royal Agric. Soc. Eng.*, 1889.

sufficient acidity had been developed when the evening's milk had a temperature of from 64° to 68° Fahr. next morning.

Professor Primrose M'Connell favours the use of whey, if it is employed with proper skill and care. He says: "The use of sour whey is one of the points which requires experience such as cannot be taught by books. It greatly aids the action of the rennet, and improves the quality of the curd if a little is used. One pint to every 30 gallons of milk is the average: more must be used in cold weather, or where the milk was previously cooled, and less in a hot season. Some of the best cheese-makers condemn the use of sour whey, on the ground that the milk will ripen itself if given time, but nevertheless it appears to be sound both in practice and theory. It certainly expedites matters by hastening the development of acidity; and as this acidity is due to the presence of the lactic or other ferments which we find in it, it appears good practice from a scientific point of view. Of course the practice must be carried out in a cleanly fashion, so as to prevent the introduction of any taint."

Mr George Gibbons, Tunley Farm, Bath, says that in the earlier and later months of the year a little sour whey may be added, but its regular use cannot be commended.

Artificial Souring Curd.—Some dairy authorities consider that, in the event of deficient acidity, it is a better plan to introduce the artificial souring into the curd than into the milk. This is done by keeping a portion of curd of the previous day's making, and mixing it with the new curd while it is being manipulated —before it is put through the curd-mill.

Professor J. P. Sheldon mentions a curious and interesting instance of the influence of acidity upon the character and quality of cheese. His father's farm, although made rich enough by improvements, somehow would produce only a second-rate cheese from the sweet-curd system pursued. "One day it happened that a few pounds of curd were mislaid until too late to include them in the cheeses of the day, and it was decided to put them into one cheese on the following day, mark that cheese, and watch the result. In this way a most valuable secret was discovered, for the truant bit of curd, which had become acid in the night, kept as it was without salt, communicated acidity to the cheese with which it was mixed, and that particular cheese was the best in the whole dairy! Afterwards all the cheese was made with a portion of old curd, and became a first-class dairy, the entire make of one year, about seven tons, realising 87s. per cwt.! Acidity, therefore, accidentally hit upon in this case, improves the character of cheese, making it firmer, and improving the flavour, as well as regulating the ripening. In point of fact, most of the mischief incidental to cheese-making is fairly attributable to the want of acidity as a feature in the process, though it does not necessarily follow that sour curd is the best way of introducing it.

"It is generally found that late autumn and winter cheese is inferior in warmth and mellowness of flavour and texture, and this may be said to be owing to the evening's milk becoming too cold through the night, and therefore not ripening as it ought to do. The most intelligent cheese-maker I have talked with, told me that he overcame this difficulty by warming the evening's milk, the following morning, up to 80°, and letting it ripen for several hours before making it into cheese. In this way the autumn cheese acquired the mellowness of the summer cheese, and sold for as much money. The milk of autumn is richer than that of summer in solids, though less in quantity, and this may be an additional reason why it needs the ripening artificially that summer milk obtains naturally. It is, in fact, a question of temperature, which is all-important in cheese-making."[1]

Measuring Acidity.—The controlling of the acidity is unquestionably one of the most important as it is one of the most difficult points in the entire process of cheese-making. There is need for more exact knowledge not only of the part which acidity plays in the making and maturing of cheese, but also of the means by which it may be developed and controlled. The chief hindrance to the

[1] *The Farm and the Dairy*, 101, 102.

proper elucidation of these matters is the want of some ready, precise, and reliable means of measuring the exact progress and strength of the acidity as it is being developed. Gray's Acidometer, a new invention, promises to be of much use for this purpose.

We will now notice in detail the methods pursued in making the different varieties of cheese.

CHEDDAR CHEESE.

The Cheddar variety of cheese, which takes its name from the village of Cheddar in the county of Somerset, has been famed for centuries. It was introduced into the south-west of Scotland by the late Mr Joseph Harding, Marksbury, Bristol, who is said to have been the first to establish the practice of Cheddar making upon a regular system. It is now extensively made in that part of Scotland, as well as in Somersetshire and other districts in England. It is also manufactured in very large quantities in Canada and the United States.

The making of Cheddar cheese has received very special study in Canada, and it is remarkable that by the employment of Canadian specialists as teachers, the system of Cheddar cheese-making in the south-west of Scotland has since 1885 been radically altered and vastly improved—a result proved by the high position which Scotch Cheddars have taken in recent London Dairy Shows, and by the higher price obtained for the cheese made upon the new methods.

One of the Canadian experts employed as a dairy instructor in the south-west of Scotland was Mr John Robertson, a Scotsman whose family have settled in Canada. To him we are indebted for the following account of "How to make first-class Cheddar cheese."

Character and Composition of Cheddar Cheese.—Mr Robertson says: Before giving the details of the operation of Cheddar cheese-making, I wish to define, as clearly as I can, what a Cheddar cheese should be, and in as few words as possible. Cows' milk, with which we have to deal in cheese-making, usually has 13 per cent of solids and 87 per cent of water. Cheese-making is the process of preserving the valuable food solids of the milk in the best possible form for human food.

A perfect Cheddar cheese should have in its composition 32 per cent of water, 36 per cent of butter-fat, 27 per cent of casein, 2 per cent of carbohydrates, and 3 per cent ash. A cheese thus composed should have a sweet, nutty, pleasing flavour. In quality it should be rich and mellow, with consistency of body, of close silky texture, true and even colour, and of prepossessing appearance and finish. To convey a still clearer idea of what a fine Cheddar cheese should be, I will define the meaning of each of the aforementioned qualities when applied to cheese, taking them as they rate in importance.

Flavour in perfect cheese I would define as the particular quality that has the power of pleasing the taste or smell; and we speak of the flavour being good or bad, just as the cheese possesses or lacks the quality to please the taste or smell.

Quality in cheese I would define as the nature of the inherent properties, relatively considered; and we speak of a rich mellow cheese as having good quality, and of a hard dry one as lacking quality.

Texture is the arrangement or combination of the parts composing the cheese; and we speak of a cheese being either silky, raw, or open in texture, as the different component parts are combined to form a smooth or grainy body of cheese, and the texture as open when the pieces of curd when pressed together do not form a completely solid mass in the cheese.

Colour of cheese might be defined as the quality that affects our sensation with regard to its hue or tint. We speak of the colour of a cheese being true when the body of the cheese when cut appears of the same tint throughout, and of the colour being untrue when the body of the cheese has a mottled or streaky appearance.

The *appearance* and *finish* is seen on the outer surface. In a cheese this would be considered good or bad as it is symmetrical in shape with a smooth clear skin, or unshapely and with a surface dirty and cracked open like baked clay.

Scale of Points in Judging Cheese.—I would give the following scale of

points of merit to each particular quality in a perfect cheese :—

	Points.
Flavour, or particular power of pleasing the taste or smell . . .	35
Quality, or properties as to richness with consistency of body . .	25
Texture, or combination of parts .	15
Colour, or evenness of hue or tint .	15
Appearance and finish, or impression produced at sight	10

Milk.—With this knowledge of the article we desire to produce borne in mind, we will now consider the milk from which it is produced. Besides its inherent tendency to decay, milk furnishes a favourable condition for the propagation of foreign ferments and parasitic fungi that are readily introduced where all of the surroundings and dairy utensils are not kept scrupulously clean; and as the introduction of impurities in this way is sure to affect the flavour and other valuable properties of the cheese, too much care cannot be given to keeping the milk free from all impurities.

Keeping and Treatment of the Milk.—In Cheddar cheese-making the evening's milk should be kept in the vat, fig. 449, to mix with the new milk in the morning. Besides keeping it where the surroundings are sweet and pure, it is important that it is not allowed to get too cold. When the milk is cold, the lactic acid or souring principle in the milk develops very slowly, and the development of that acid to a certain extent is considered essential in the making of fine cheese. When the milk can be kept at such a temperature and depth as to gradually cool down from its natural heat to 68° Fahr. in the morning, it should be in good condition to mix with the new milk; and when kept warmer than 68° or 70° Fahr., the lactic acid would, in most places, be too far developed to allow sufficient time for the proper working of the curd.

Testing Ripeness of Milk.—An idea of the ripeness or development of the lactic acid in the milk may be had by using 4 oz. of milk, or an ordinary teacup about three-fourths full, and adding a teaspoonful of rennet extract, noting the number of seconds that it takes to thicken. This can readily be seen by allowing a short bit of straw or mote to float on the milk. The motion given to it by stirring the rennet in the milk for a few seconds will be stopped as soon as the milk thickens. In spring months, from fifteen to twenty seconds is a very good time to have it thicken in; and in the summer months from twenty-five to thirty-five seconds. A standard tested rennet extract should be used. But a careful watching of the temperature of the evening's milk in the morning will give one quite as accurate an idea of the ripeness of the milk as any method known, provided the milk is always set nearly the same depth.

In testing the ripeness of the milk with rennet see to it that the milk used is always at the same temperature, as heat is a favourable condition for rapid rennet action, and cold an unfavourable condition. When the evening's milk is too cold in the morning, it is advantageous to heat it a few degrees warmer than usual, and allow it to cool again, the heat facilitating the development of the souring before the rennet is added.

Cream.—The thick cream should be removed from the evening's milk, and warmed by pouring a portion of new milk amongst it, and left to dissolve again, till fifteen minutes before the rennet is added. In this way it is more thoroughly incorporated into the body of the milk again, when poured through the strainer and thoroughly stirred in the milk.

Colouring.—When colouring is to be used, it should be added as soon as the whole quantity of milk is together in the vat, fig. 449. An ounce and a half of annatto per 100 gallons of milk gives a medium bright colour. From 1 to 2 oz. per 100 gallons are commonly used, according to brightness of colour desired. The colouring should be diluted in not less than five times its bulk of pure water, to facilitate its thorough incorporation into the milk. The practice of using artificial colouring is being very properly discouraged.

Adding the Rennet.—From 84° to 88° Fahr. are good temperatures at which to add the *rennet;* 88° in the early spring and autumn months, when the milk is likely to be very sweet; 84° in very warm summer days; and 86° in moderate weather.

Pure *rennet* of known strength should be used, and that also should be well diluted with pure water to ensure its rapid and even distribution throughout the milk.

Quantity of Rennet. — In spring months sufficient rennet should be used to thicken the curd ready for cutting in thirty minutes, and in the summer months in forty-five minutes. When the rennet is added, stirring of the milk should not exceed five minutes, as the milk should be quite still when coagulation begins. The surface may advantageously be slightly agitated by passing the bottom of the dipper lightly over it, to prevent the cream from separating till coagulation has commenced.

From 4 to 5 oz. of rennet extract per 100 gallons of milk is usually sufficient in the spring months, and from 3 to 4 oz. in the summer months.

The Curd.

Cutting.—The *curd* should be ready for cutting when it splits clean before the finger, when inserted at an angle of about 45°; or, if note is taken of the time at which the rennet was added, till coagulation is perceptible, and the curd is left as long again and a half. Coagulation should by that time be complete, and the curd ready for cutting. Horizontal and perpendicular curd-knives (fig. 453) should be used, and the

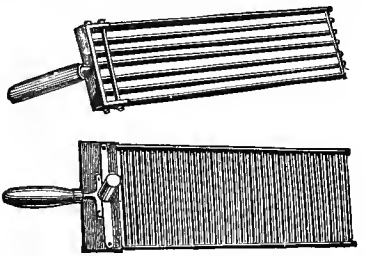


Fig. 453.—*Curd-knives.*

cutting should be done very gently and slowly, taking at least half an hour to reduce the curd to pieces as small as peas.

The cutting of the curd is done to facilitate the escape of the whey, and allowing the curd to settle for fifteen minutes when the cutting is completed, is another help to expel the surplus whey from the structure of the curd.

Heating.—Heat should then be applied very slowly, where steam is used for that purpose, the temperature being raised at the rate of one degree in from four to five minutes. Rapid application of the heat at this time forms a skin on the pieces of curd, and thus prevents the proper expulsion of the whey from the curd that the heating is intended to accomplish. The heat in the modern vat is applied, as we have seen, by circulating hot water or steam between the two casings of the vat; and in the old-style circular tub by heating whey and pouring over the curd.

In spring months the heat should be raised to from 98° to 100° Fahr., and in summer and autumn from 100° to 102°. Gentle stirring of the curd should be continued during the process of raising the heat, and from twenty minutes till a half-hour after the heat is raised.

Firmed or "Cooked."—The curd may then be allowed to settle, and if not firm enough to spring apart when slightly disturbed after having been squeezed firmly in the hand, it may with advantage be stirred up occasionally, until that degree of firmness has been attained. It is important in the making of a good-keeping, sweet-flavoured cheese, that the curd is properly firmed or "cooked," as it is commonly called, before there is any sourness or acid perceptible to the taste or smell. When the curd is properly "cooked," the whey should not be drained off till acid is quite perceptible.

Testing Acidity.—A good test of the *acidity* may be obtained by squeezing a handful of the curd as dry as you can, take a piece of it as large as a walnut, and apply it to a hot iron just warm enough to roast it without burning. When applied with light pressure, and when removed slowly from the iron, if a number of fine silky threads draw out a fourth of an inch, the whey should be removed at once, and unless the curd is firm and well cooked, the whey should be removed when the silky threads draw out an eighth of an inch. With the milk in good condition the time of cooking, from the time the heat is raised till the acid should show as above, varies at different places from one hour to two hours.

Draining.—As soon as the whey is

drained off, the curd should be removed from the tub or vat, and placed on racks or drainers covered with a cloth through which the whey may readily escape. Unless the curd is very firm and dry, it should be gently stirred for a few minutes to prevent it matting at once, thus facilitating the escape of the whey.

Packing.—The curd should then be *packed* to a depth of 5 or 6 inches, and well covered to maintain the heat. In twenty minutes after packing it should be cut into pieces about 6 inches wide, and 8 or 10 inches long, and turned, care being taken not to allow the curd to cool very much. After turning three times at intervals of twenty minutes or half an hour, the curd may be piled up deeper to maintain the heat throughout the whole alike, and thus develop the acid equally throughout the entire mass of curd. But in cases where the souring is developing rapidly, it is best not to pile the curd deep.

Milling.—When the acid has developed so that fine threads from 1½ inch to 2 inches draw out on the curd when applied to the hot iron, the curd should be put through the curd-mill (fig. 450). That much of the butter-fat may not be bruised out in the milling process, it is advantageous to spread the curd to allow it to cool before milling. But the cooling should not be below 80° Fahr.

The curd at this stage of the process should have a smooth velvety feel, with a flavour like well-ripened cream to the smell. The length of time from placing the curd on the rack till milling varies from 1½ to 2½ hours.

Salting.—After stirring the curd well for a few minutes, salt at the rate of 2 lb. per 100 lb. of curd should be thoroughly stirred into the curd. This quantity is best suited for the early months, and after the month of May 2¼ lb. salt per 100 lb. of curd should be used. After salting, the curd should be left 15 or 20 minutes to allow the salt to thoroughly penetrate the curd before putting it in the chesset, mould, or hoop, as it is variously called (figs. 454 and 455, John Gray).

Pressing.—Unless the curd is very soft and buttery it should not be allowed to cool below 78° to 80° before packing into the chesset. Pressure should be applied to the curd in the chesset very lightly at first, just sufficient to start the whey running being enough, and gradually increased to 2 or 3 tons weight, that the curd may be made a completely solid

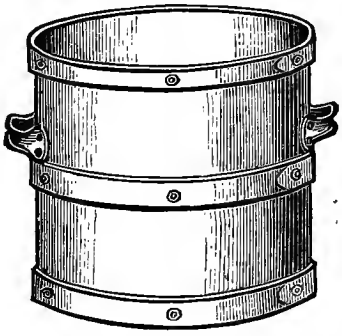


Fig. 454.—*Metal chesset or cheese-mould.*

mass. It should be kept in press for 8 days, and should be turned each day, and a dry cloth exchanged for the one it is pressed in.

Smooth Skin.—Turning the cheese the same day on which it was made helps to secure for it a smooth skin, and care should be taken that the *cheese-*

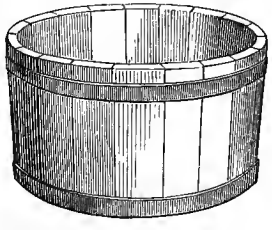


Fig. 455.—*Wooden chesset or cheese-mould.*

cloths are not greasy, thus preventing the pieces of curd from sealing closely together to form a skin that will not readily crack.

Hot Bath.—After pressing overnight, the cheese should be treated to a *warm bath* in water about 120° Fahr., to ensure giving it a smooth rind.

Curing.—The cheese, when taken out of the press, should be carefully *bandaged*, and the ends well rubbed with fresh fat before being put away in the curing-room. Allowing the surface to get exposed and dry tends to crack the cheese.

Curing-room. — The curing-room should be kept dry and well ventilated, and a steady temperature of about 65° Fahr. should be maintained. A warmer temperature than the above will ripen the cheese quicker, and a lower one slower. The cheese should be turned each day in the curing-room, and the apartment as well as the cheese should be kept bright and attractive. Carelessness in this particular very often gives a merchant a bad impression of the cheese, and makes him indifferent in buying.

Cheese carefully made and kept in this way should be ready for use in from 2 to 3 months, and it should keep well for months afterwards, if required.

Other Methods.

Professor Primrose M'Connell thus describes briefly a method of preparing the curd pursued very largely in this country in Cheddar making: Where there is a daily making of cheese, the evening's milk is set in the vat or in coolers, so as to ensure that it will fall to a temperature of 66° Fahr. by morning —or it may be passed over the aerator. In the morning the cream is taken off, the morning's milk mixed with the previous milking, and the cream warmed to 75° Fahr. and returned to the mass through a sieve, for the purpose of ensuring thorough mixing. The whole is then heated to 90° Fahr. in spring, or 84° to 86° in summer (according to temperature of the air—a lower temperature requiring the higher heating), when it is allowed to rest for some time to acquire a certain degree of acidity or "ripeness." After this the rennet is added, when it has cooled down to 82° to 84° Fahr., and well stirred in. About 1 pint to 400 gallons of the "artificial" varieties being required, or 1 pint to 100 gallons of the old home-made kind.

When the milk is sufficiently coagulated, which it ought to be in from 30 minutes to 1 hour, the curd is cut with the curd-knives (fig. 453), one of which should be for horizontal and the other for vertical cutting; or it may be cut by the curd-breaker (fig. 456). This latter is made with tinned steel blades, either vertical or horizontal, and with a long or short handle. The object is to cut, *not break*, the curd slowly into small pieces, for the purpose of letting out the whey. When the curd has been cut by repeated stirring into pieces as big as beans or peas, and begins to become firm, the temperature (which should not be allowed to fall below 80° Fahr.) is gradually raised to 100° Fahr. (or 98° in hot weather), and the whole kept stirred with the curd-stirrer, a utensil similar to the cutter, but made with round wire, instead of thin steel blades. The stirring is continued until the curd attains a certain degree of firmness, which requires practical skill to know, but cannot be described. From beginning to end, the cutting and stirring occupies about 1½ to 2 hours. At the end of this time, the curd is allowed to settle and lie till it is sufficiently "cooked" in the whey. A good judge knows by the feel when it is ready; others use a hot iron to which a piece is applied, and if it melts and draws out into threads, it is considered "ripe." The whey is then run off by a tap or siphon, the curd taken out, placed in an oblong trough with a sparred false bottom, on which a cloth has been spread, and then broken down by hand, turned, and allowed to lie in a heap to drain and develop acid.

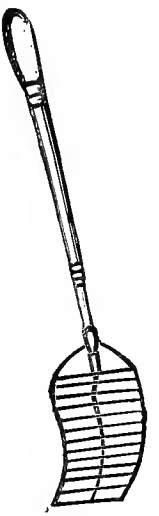


Fig. 456.—*Curd-breaker.*

The curd is then put into a large chesset, known as the dripper or drainer, put into the press and subjected to a pressure of ½ ton to get rid of the whey. It is taken out of the press, sliced-up with a knife, put through the curd-mill, salted with refined dairy salt—usually at the rate of 1 lb. of salt to 50 lb. of curd —and it is then ready for packing in the chesset for final pressing.

The system thus described by Professor M'Connell prevailed in Ayrshire prior to 1884, but it has now been largely superseded by the method detailed by Mr Robertson.

Mr Gibbons's System.—Mr George Gibbons, Tunley Farm, Bath, a well-

known authority on dairying, describing the system of making Cheddar in small or medium dairies (where there is no arrangement for heating the curd in the vat by circulating hot water or steam between the casing of the vat as already described), says:—

"This done [the first cutting of the curd in the tub], it should be left to harden a few minutes and for the whey to separate, when, by the use of a shovel-breaker, the splitting of the curd in its own grain commences. This at first must be done with the greatest caution, or the whey will get white and loss of quality ensue; but the speed should increase as the curd hardens—always taking care that it is regularly broken, and not smashed, until it is the size of a pea, and the whey of a greenish hue; the time of this operation depends somewhat upon the quantity dealt with, but it should take from fifty to sixty minutes. The mass should now be allowed to settle for ten minutes, when with a siphon sufficient whey may be drawn off, which, when heated to not more than 130°, would raise the whole to 90°. During the application of this whey the curd should be well stirred and mixed. A further rest of ten minutes takes place, when enough whey should be drawn off for heating to 130°, and the whey in the tub lowered till it only covers the curd by about two inches. The heated whey should now be poured in a small stream over the curd, the operator taking the utmost care that the whole mass is thoroughly broken up and incorporated with it, the thermometer being frequently used, until it stands at 100°, the limit desired; but the stirring must be continued until the curd becomes shotty and is disposed to sink, the whey showing above it clear and green.

"This operation may take from ten to thirty minutes, but should the curd not harden sufficiently fast, and the temperature fall quickly, it would be well to add more hot whey, so as to retain the heat at 100°. The curd may now rest thirty minutes (or, if it is sufficiently acid, a shorter period will do), when all the whey may be let off, and the curd piled as high as possible in the centre of the tub. Carefully wash down all crumbs, strain, and place them on the top of the mound. Cover and keep it warm with cloths until it has become sufficiently solid to cut into large pieces which can be turned over without breaking. When this has been done, the whole should be again piled and kept covered for thirty minutes longer, as before; after this it may be removed to the curd-cooler, cut into smaller pieces, and again piled and covered for thirty minutes. This cutting, changing, piling, and covering is continued until the curd presents a rich, dry, mellow, solid appearance, and a perceptible amount of acidity has been developed. This is easily ascertained by taste and smell. It is now ground, and should present a ragged solid curd, dry, but greasy; and if several pieces are pressed together by the hand, the fragments should easily fall apart. Fine clean dry salt should be used at the rate of 2¼ lb. per 112 lb. of curd, and thoroughly mixed with it. At this point the temperature of the curd should not be below 70°, and it should be put into the vat or mould, lined with a thin cloth large enough to cover the cheese, placed in the press, where it has a pressure of about 20 cwt., and allowed to remain there until the next morning, when the cloth should be changed, the position of the cheese inverted, and replaced in the press until the following morning. A little fat rubbed over it softens the surface, and is useful in preventing cracks, a square piece of muslin being placed on its top and bottom, and the sides also completely covered with the same material, of sufficient width to draw over the squares 1½ inch, to which it should be neatly sewn. Replace the cheese in the press, where it should continue two days longer. It should then be stoutly bandaged and removed to the warm cheese-room, whence, after being turned daily for six weeks, it should be taken to the cooler room, and turned every other day until three months old, after which, turning once every four or five days is sufficient. Much trouble and damage to the cheese is saved by the use of vats which open with a key.

"Some successful makers scald at a lower temperature, only raising the first scald to 86° or 88° by whey heated to 120°, stirring the curd to assist the hardening fifteen or twenty minutes. The temperature of the second scald should

be 98°, by whey heated to 130°, and it should be stirred until the curd is shotty. It should then be left for twenty minutes, or less, if acidity develops fast. In this case no whey is removed from the curd previous to scalding, except what is required for heating. After the expiration of the time of rest, let all the whey run off; then the usual course is to place the curd in the centre, cutting, turning, covering, and keeping warm, putting it on a rack to drain, placing a board and heavy weights on it to facilitate separation of the whey, promote acidity, and produce a solid curd."[1]

To obviate the laborious work entailed in lifting and carrying the whey to be heated, Mr Gibbons recommends for large dairies the use of improved appliances made by E. S. Hindley, Bourton, Dorset, whereby the quantity of milk or whey required for heating is raised by a small centrifugal pump to a tin or copper-tinned vessel called the heater, placed on a level with the top of the tub, and partly overhanging it. The heater has a double bottom to admit steam underneath to heat the whey or milk, which, when a tap is opened, runs back into the tub to heat the mass of milk or curd and whey to the desired temperature.

STILTON CHEESE.

Professor J. P. Sheldon gives us the following notes regarding this famous cheese: In appearance and character quite distinct from any other kind of British cheese, save the Yorkshire Cotherstone, which resembles it more in looks than anything else, Stilton cheese is at once one of the most modern and perhaps the most famous of all the many different kinds that are produced in the British Islands. A hundred years ago it had a local reputation in the district around Melton Mowbray, chiefly because the well-known Cooper Thornhill, who kept the Bell Inn at Stilton, on the Great North Road between London and Edinburgh, had it always at hand to regale travellers in the old coaching days. It was first made by Mrs Paulet of Wymondham, a relative of Thornhill's, whose customers were sometimes "gratified" with it "at the expense of half-a-crown a pound,"—so we are told in Marshall's *Rural Economy*, which was published in 1790. It thus received the name of "Stilton cheese"; and the place where, as well as the method on which, it was made, was kept secret for some time. At length, however, the place and the method became known, and it was then made at various farms in the counties of Leicester and Rutland, while in modern days it has been produced in many parts of England, in the United States of America, in Canada, and elsewhere.

Characteristics.—The distinguishing feature in the old-time Stilton method of cheese-making was the presence in the milk of a double quantity of cream—that is, the cream of the evening's milk was added to the morning's milk, which was then made into cheese. Hence, indeed, its superior quality, and the price it used to command. True Stilton cheese is still a double-cream cheese, wherever it may be made; but in modern times its reputation has suffered, because a great deal of so-called Stilton has been made from milk without the added cream, in which event it has no higher quality than ordinary cheese made on other methods, though the Stilton method gives a different character to the product.

Climate and Soil.—It is said that no other county can produce Stilton cheese equal to that of Leicester and Rutland, soil and herbage having so much to do with the result. It is probable, however, that this claim cannot be sustained, and that the finest qualities of Stilton can be produced elsewhere, on the same method, with a double quantity of cream, and from rich old pasture-land. It is also said that really fine Stiltons can only be made in the five months beginning with May and ending with September. This is probably correct, but the statement is equally applicable to other kinds of cheese.

Method.—The Stilton method is as follows: The evening's milk is put into shallow "leads," or pans, and is skimmed next morning, the cream being mixed with the fresh milk of the morning. The rennet is added when the milk has been raised to a temperature of 83° Fahr., and coagulation is perfected in an hour afterwards. The coagulum is then broken a

[1] *Jour. Royal Agric. Soc. Eng.*, 1889.

little and very gently, after which it remains at rest for a quarter of an hour; it is then put into the "leads," over which cloth strainers have been spread to receive it, and the whey drains slowly out of the curd. As the draining proceeds, the corners of the cloth are tied closer and closer, until the curd becomes tolerably firm and dry. The curd is then put into a tin strainer and cut into squares, remaining so until it is ready for the hoops, at which stage it is carefully broken into small pieces. A layer of curd is then put into the hoop, and on it a sprinkling of salt, care being taken not to let the salt get too near the outside; then another layer of curd, and on it salt as before, and so on until the hoop is full, when the mass of curd is lightly pressed down in the hoop.

The hoop is a cylinder of perforated tin, but without bottom or top, and it is placed on a shelf over which a cloth has been spread, and where the whey may still drain away. The hoop is turned "other end down" two or three times a-day, until the cheese is firm enough to be taken out of it, the time required being from five to ten days, or even longer, according to the temperature. The cheese is then bound tightly round with a cloth, which is repeatedly changed for a dry one, until the crust of the cheese has firmed, and the shape can be maintained without the aid of cloths. The cheese is then placed on a shelf in the cheese-room, where it ripens, and the blue mould so highly prized is developed—a process, as a rule, occupying a good many weeks.

No curd-mill is used in the Stilton method, and the cheese is not put into press. Grinding the curd, indeed, would liberate the cream, a portion of which would be lost in the draining, and pressure would cause more of it to escape. In a double-cream cheese, the danger is obvious; and even in single-cream cheese there is always a loss of butter-fat through grinding and pressing. In the Stilton method, the curd is a good deal exposed to the air. This oxidises it and causes a little acidity to develop, which facilitates the escape of the whey, the ripening of the cheese, and the development of the blue mould—*Penicillium crustaceum*—which has its influence not only on the consistency but also on the flavour of the cheese. The measure of the operation is governed by temperature, in respect of which, as of the whole process of manufacture, the Stilton cheese-makers do not appear to have laid down any general or definite rules.

CHESHIRE CHEESE.

The system of cheese-making pursued in Cheshire corresponds pretty closely with the Cheddar method.

Four processes differing in minor details are here practised—an early ripening process, medium ripening process, late ripening process, and the Stilton-Cheshire process. The difference in the first three lies mainly in the amount of acidity developed, and the amount of pressure applied.

In the early ripening process about 50 per cent more than the usual quantity of rennet is added, while more acidity is developed and less pressure employed than in the other methods. In the medium ripening process a moderate amount of acidity is developed, to ensure the draining of the whey from the curd under pressure. In the late ripening system acidity is as far as possible prevented, the whey being drained by breaking down the curd more finely, and skewering under press, while the milk and curd are raised to a higher temperature in this method. In the Stilton-Cheshire system a large quantity of rennet is used, and little pressure is employed. An open flaky curd with little acidity is desired for this cheese.

OTHER ENGLISH VARIETIES.

Many other varieties of cheese are made in different parts of this country. In few instances, however, has a clearly defined or recognised system of manufacture been established, as in the case of Cheddar cheese.

The most widely known of these other English cheeses are the Leicestershire cheese, "single" and "double" Gloucestershire cheeses, Cotherstone cheese, Wensleydale cheese, and the cheeses of Derbyshire, Lancashire, Wilts, and Dorset. In Scotland the Dunlop cheese still maintains a local habitation, and a name more than local.

Cotherstone cheese is a copy of Stilton, little used outside Yorkshire, where it is made. The *Wensleydale* cheese, also a Yorkshire article of only local repute, is made at a high temperature, so that coagulation takes place in from thirty to forty minutes. The process is short and simple, but the cheese is not of a high class. After being pressed for twenty-four hours, the cheeses, which are usually under 15 lb., float in brine for three days, and are salted by that means. The *Glo'ster* "single" and "double" cheeses are flat and level, the latter being double the thickness of the former. They were at one time more widely esteemed than now.

Cream Cheese. — This is a fancy cheese, relished by many people. As indicated by the name, it is made from cream, and is of course the richest cheese made in butter-fat.

Professor Sheldon thus describes the making of cream cheese: "Cream cheese is easily made by pouring thick cream into a perforated box of wood, which is lined with muslin. The box may or may not have a bottom, and it should stand where the moisture from the cream can drain away. As the wet leaves it, the cream gradually hardens and becomes fairly solid, when it may be taken out of the mould and placed on straw exposed to the air. A blue fungus soon appears on the crust, and the cheese is ready for eating.

"It is made in a cool room, and should become slightly sour. Though there is less art and work in making cream cheese than in making any other sort, success is not always attained at the outset, and it must be remembered that cream cheese will not keep long.

"The cooler the room the slower the cheese will ripen, and indeed it should not ripen quickly. A room whose normal temperature in summer is 60° to 65° Fahr. will serve the purpose well enough, and in winter the temperature may be artificially raised if need be.

"The demand for cream cheese is limited and irregular, and the price at which the producers will find a profit is one which will not encourage a large circle of consumers." [1]

[1] *The Farm and the Dairy*, 86.

Ordinary cream cheese is made with one part of cream to two parts of milk, rennet being added to curdle the mass in from six to eight hours.

Skim-milk Cheese. — Skim-milk cheeses are made in several parts of the country, chiefly in Scotland, but without the addition of some portion of cream the cheese is dry and rather tasteless.

An attempt has been made, chiefly in America, to replace the fat removed in the cream by the introduction of lard or other animal fat into the skim-milk. But the oleomargarine cheese thus produced is an inferior article, which has been very properly classed as a "dairy abomination."

Keeping Milk for Cheese-making.

The general plan, we have seen, is to make cheese every day. But on many small and mixed husbandry farms a sufficient quantity of milk is not available to make a cheese daily. In these cases the milk may be kept over one or two days, and a cheese made every second or third day. When it has to be kept for this purpose, the milk is cooled as soon as drawn from the cow, and kept in a cool place. When the cheese is to be made, the cream is taken off the stale milk, some fresh milk added, more fresh milk is heated up to perhaps 150° Fahr. (not to boiling-point), and added, and the cream which was taken off mixed with its own bulk of milk, and heated to 98° Fahr., and also added,—the whole being well stirred, and the rennet then put in.

If the milk has to be kept longer than one whole day and night, it is difficult to make really good cheese from it. Yet in many cases it has to be kept over two days in order to collect a sufficiency for cheese-making.

Different Makings of Curd.—Cheddar cheeses usually weigh from 80 to 90 lb. each. Mr Robertson, Dairy Instructor, Wigtownshire, gives the following directions for making an 80 lb. Cheddar cheese with 40 gallons of milk to make into curd at one time:—

"Let the curd of the first 40 gallons of milk be put into the chesset or mould, and pressed as if the cheese were finished, and then when the curd of the next 40 gallons is ready, scratch the surface of

the curd in the chesset with a dinner fork, or anything that will make the surface quite rough, gather the loose curd thus broken up towards the centre of the chesset, and pour a little warm water around the edge of the chesset on the inside, and pack in the fresh curd and press as usual. The splice thus made will most likely be complete, without any danger of cracking, or the cheese parting into halves. Of course this method should not be pursued except where there is not a sufficient quantity of milk to make enough curd at one time for an ordinary-sized Cheddar cheese.

"Where there are smaller quantities of milk to be handled daily, I would consider some method of making soft cheeses preferable to an attempt to make Cheddar."[1]

It is a better plan to make small cheeses frequently from fresh curd, than larger cheeses more seldom from mixed stale and fresh milk or curd.

FOREIGN CHEESES SUITABLE FOR BRITAIN.

The following notes regarding foreign varieties of cheese capable of manufacture in this country, were prepared for this edition by Professor James Long:—

The varieties of cheese made upon the Continent of Europe is much greater than can be realised by those who have not examined the subject. Those cheeses which are suitable, however, to British trade and taste are not numerous, and are practically included in the list, details of the manufacture of which are given below. France claims the longest record, after which come Italy, Switzerland, and Germany. In Germany there is no specially leading variety, such as is universally recognised as a leading cheese, as in the case of the Gruyère for example. Nor do we find any important cheeses in such well-known dairy countries as Sweden, Norway, or Denmark.

Gruyère.

This cheese, which is made chiefly in Switzerland, and in those departments in France bordering upon that country, is well-known in England. It is of great size, weighing from 100 to 150 lb., and often being more than 2 feet in diameter and 6 inches in thickness. It is a cheese which, at its best, is mellow, melting on the tongue, homogeneous, a light yellow in colour, without cracks on the crust, with a number of small holes which should not exceed three-eighths of an inch in diameter. The interior of these holes is moist, and the walls glazed, and they usually contain a little brine. The flavour is at once rich and nutty, somewhat resembling the very best Cheddars.

Gruyères are made in three qualities, —fat, half-fat, and lean,—or from full milk, half skim-milk, and skim-milk respectively. Most of the cheeses are made at factories or *fruitières*, to which the milk is delivered by the small producers.

It is warmed to 93°, and the curd brought by means of rennet in from 25 to 35 minutes. It is then cut with a long wooden knife, and subsequently stirred until the pieces of curd are no larger than peas.

The operation takes place in a handsomely made vat, or kettle of copper, frequently 5 feet in diameter. This kettle hangs upon a crane, and is swung over a wood-fire in the floor. Sometimes it is fixed, and the fire, made in a movable grate upon wheels, is run on a pair of rails from kettle to kettle.

The curd is next heated up to 135°, the stirring continuing until it has reached a proper consistence, which can only be ascertained by experience. The whole is then allowed to settle, and the cheesemaker skilfully passes a cloth beneath the curd, which has settled at the bottom of the vessel, brings up the ends on the other side, attaches the four corners to a hook hanging from a pulley, and in a few moments the curd is swung over a table and dropped into a mould waiting to receive it.

This mould is open at the side, and can be tightened at will. When once within it, the curd is carefully wrapped up with cloths, and after standing for a short time, it is put under a press for the removal of the whey.

It is salted the next day, the salting continuing from day to day for a considerable period, two men being required

[1] *Farming World Year-book*, 1890.

to move the cheeses, which are placed upon shelves in the ripening room.

Here three temperatures are, if possible, introduced, at the lowest, middle, and top shelves. These temperatures vary between 52° and 60°. Poor, or skim-milk, is set at a lower temperature than that given. What art there is in making Gruyère is chiefly displayed in the judgment in removing the curd from the vat at the right time, and in properly pressing, salting, and ripening it.

The other cheeses made in Switzerland, but all of which are unknown in the ordinary markets of this country, are the Spalen, the Bellelay, the Battelmatt, the Vacherin, the poor man's cheese, and the Schabzieger, in which the sugar of milk plays an important part. This cheese resembles the Myseost of the Scandinavian countries, and is not likely to become an important article of commerce.

Dutch Cheeses.

The two important cheeses made in Holland, both of which are sold in the English markets in very large quantities, are known as round or *Edam*, and flat or *Gouda* Cheese. We have seen these cheeses made in various districts in Holland, and have found that, although the systems adopted are similar, they vary in minute details, such as temperature.

Edam.—A round Dutch cheese weighs about 5 lb. The milk is sometimes partially skimmed, but the best makers remove no cream from it. The cows are milked in the meadows, and the milk—placed in round wooden tubs, which are taken to the cows by boat along the dykes which divide each farm—is renneted before starting for the dairy, at from 85° to 90°.

The curd usually forms in from 15 to 30 minutes, in accordance with the custom on the farm, and it is slowly cut with a wire cutter during 10 minutes, when the whey commences to separate.

The colouring is added with the rennet, if it is used.

After manipulation with the hands, the whey is baled out with a ladle, and the curd gathered together and again worked. As no mill is used, it is broken in the tub, and more whey removed, after which it is gathered together in a round mould and pressed for a short time. This pressing continues until sufficient whey is removed, when the curd is placed in a trough in an egg-cup-like mould, with a lid which gives it its circular form. In this it is placed under a unique lever press, which is common in Dutch dairies.

Next day some salt is placed upon the top, but the cheese is reversed from time to time, while always being salted from the same point. This continues for from 8 to 10 days, when it is put into a vat of thick brine for from 12 to 24 hours, being subsequently washed and removed to the ripening room, where it stands upon a shelf, as near as possible at 70°. The cheese is turned daily until it is fit to sell.

It is well rubbed with linseed-oil and coloured yellow or red, in accordance with the market to which it is destined, the surface being scraped smooth and fine.

This cheese is made to an enormous extent in the provinces of North Holland, the chief markets being Hoorn, Edam, and Purmerend, all of which are within a convenient distance of Amsterdam.

Gouda.—The *Gouda*, or flat Dutch cheese, when at its best closely resembles the fine flavour of English Cheddar. It is much larger and heavier than the Edam, and although flat, has rounded sides. It is generally possible to purchase cheese of prime quality in Amsterdam, although its very high price prevents any considerable sale in this country. The milk is set at 92°, sufficient rennet being added to bring the curd in 25 minutes. It is then cut either with a knife or a lyre-like implement common among the Dutch.

As the whey exudes, it is removed from the tub, and the curd carefully and gradually broken up into fine pieces with the hands. It is subsequently pressed and squeezed in a large perforated basin-like mould, in which it is again pressed for the removal of the whey.

The cheese afterwards goes into the mould which gives it its shape, and in 24 hours is salted, salting continuing from day to day until it is fit for the brine-vat, where it sometimes happens that hot water is added to the curd after the withdrawal of the whey, in order to

harden it. This is a rougher plan of heating up than the operation as performed in England.

The Dutch cheeses are undoubtedly a boon to the working classes, who prefer them to inferior home-made cheese at similar prices.

Parmesan.

Parmesan cheese is manufactured in Italy, chiefly in Parma and Emilia. It is generally known as Grana, on account of the fine grain into which the curd is brought during manufacture. In size and shape it resembles Gruyère, but often weighs more than 150 lb.

Parmesan requires keeping for a considerable period, sometimes three years, until it is fit for the market, and for this reason the export trade is in few hands, the makers being obliged to sell to the dealers while the cheese is new, for they complete the process of ripening in the marvellous caves which are built beneath their premises.

The true Parmesan is full of minute holes, and when cut in halves emits a sticky sweet substance, which has caused the term "honeyed" to be applied to cheeses of the finest quality. The flesh of the cheese is a pale straw colour, but the crust is often almost black from its age and the colour which has been applied to it. Like the Gruyère, the Parmesan is made in factories, where the milk is carried by small farmers, as in Switzerland. In one of these establishments, where we were enabled to learn the process, as many as eighty persons brought in their milk, varying from 4 to 60 litres apiece. The work was done by two men.

The milk is put into a kettle of solid brass, and resembling in shape an inverted bell. This hangs from a crane over a fire in the floor. The milk is heated to 92°, when the cheese-maker takes a piece of solid rennet, the size of a walnut, which he places in a cloth, and dipping this into the milk, wrings it for some minutes, until its virtue has passed into the milk. The strong-smelling animal matter is then thrown away.

The curd is sometimes brought in fifteen minutes. It is then roughly cut, and subsequently broken up with two implements — one called the *rotilla*, a long staff with wire-work bound around its head, and the other a rod with a disc at the end. Stirring is continued until the grain is almost as fine as large shot; some cold water is then sprinkled over the surface, the kettle is swung over the fire a second time, and the milk heated to from 104° to 110°, stirring being continued the while.

When the Grana, which is continually tested, is fit, the whey is dipped out, and the curd, which has been pressed into the bottom of the kettle, is removed into a cloth by two men, and placed in a large vessel for half an hour, after which it is removed into the mould. Here it is wetted with whey two or three times, in order to keep it sufficiently flexible; but it is also pressed by lying between two boards, and having weights placed upon the top.

The cloths are removed from time to time, when the cheese is covered with buckram, which gives an imprint to the skin. The buckram is subsequently cut, and the cheese is salted and again pressed. This process continues every other day for a fortnight, when the cheese is cleaned and scraped and taken to the ripening room, where it is greased and turned from time to time at suitable temperatures until it is ripe. In the ordinary way, however, it is sold to the dealer while it is yet young and green, very few of the makers venturing to complete the ripening process.

Gorgonzola.

This blue-moulded cheese, which somewhat resembles Stilton, is made chiefly in Lombardy, in moulds which are 12 inches in diameter by 12 inches high.

The curd is chiefly prepared by owners or drivers of cattle, and sold to the merchants when it has become solid, and formed into a cheese to ripen. The practice is to add the rennet to the evening's milk while it is from 85° to 95°, so as to bring the curd in fifteen minutes. It is then cut and broken up and ladled into cloths, which are hung up to drain in a cool apartment until the following morning.

The milk of the morning is served in a similar manner, except that the cloth holding the curd is placed into a bucket or vat to drain for some ten to fifteen

minutes. At the end of this time the curd of the evening, which is cold, and the warm curd of the morning are placed in the cheese-mould, care being taken that the top and bottom, as well as the sides, are composed of the warm curd. The middle of the cheese is built up of alternate layers of cold and warm, the maker plunging his fingers occasionally into the mass to amalgamate them.

When filled, the cloth which envelops the curd is folded over the surface, and the cheese is allowed to settle until it has sunk into the lower half of the mould—for it is divided into two pieces; the top portion is then removed and the lower one reversed, that the cheese may drain and face better.

At the end of twelve hours it is again turned, and the mould tightened. Next day the cloth is removed, and the cheese begins to take its form.

It is then removed into an apartment of 65°, where it remains for three or four days, at the end of which time the mould is removed altogether, and salting commences.

One-half of the cheese, and that always the top, is daily sprinkled and rubbed with salt, being reversed the following morning. This salting continues until, in the judgment of the maker, sufficient has been given; brining then goes on for a few days, and the cheese is next taken to the cave, which must be cool and moist, and is preferable if a damp draught is passed through it.

By this time a red mould has commenced to grow over the surface, and the cheese now requires great care in management and frequent turning. In from four to five months it will be ripe for the market, and will be veined throughout the interior with green mould.

The following analyses of Gorgonzolas, some of which, it may be mentioned, are made without any mould, for the higher Italian classes, many of whom prefer it, as the green fungus has been at times produced by artificial means, which are objectionable:—

German Analyses.

		Soxhlet.
Water	36.72	43.56
Fat	33.69	27.95
Casein	25.67	24.17
Salt	3.71	4.32

Professor Kinch's Analysis.

	White.	Blue.
Water	48.99	24.96
Fat	26.50	26.10
Casein	21.11	43.46
Salt	3.40	5.22
Sugar	...	.26

The analyses by Professor Kinch were of cheeses made under the direction of the writer, at the Royal Agricultural College, Cirencester—10 gallons of milk made from 14 to 15 lb. of cheese.

Roquefort.

This cheese, also somewhat popular in this country, is made in the Aveyron, in France, from the milk of the ewe, some half-million of these animals being kept in one district alone for the purpose.

The Roquefort is a small, round, flat cheese, weighing about 5 lb., and, like Gorgonzola and Stilton, it is veined with blue mould. This, however, is obtained in a different way, as will be seen.

The evening's and morning's milks are mixed together, and brought to a temperature of about 90°; the rennet, which is made from the stomach of the lamb, is added, and the curd brought in a short time.

It is then cut and broken down, and much of the whey removed. The curd is afterwards conveyed into the mould in three layers, between each of which a quantity of specially prepared mouldy bread crumbs are sprinkled, the bread being made from a mixture of wheat and barley flour.

After pressure, and when the cheese has attained a distinct form, it is removed to the drying-room for two or three days, when it is carried to the celebrated caves which have made the district so famous, and which are extremely humid, the temperature being about 46°. Here it is from time to time scraped, as mould grows upon it, salted, and ripened. Machines, however, are now used in some instances for brushing the rind instead of scraping it, and also for piercing the cheeses with needles, in order to encourage the growth of the fungus within.

Cantal.

The Cantal cheese, which is an extremely important one upon the Con-

tinent, and which is probably destined to make its appearance in this country, is chiefly made in the Auvergne, and varies in weight from 40 to 100 lb. It is of piquant flavour, has a solid consistence, and may be termed a hard cheese.

Cantal is made from milk at a temperature of 75°; the curd is broken up in an hour, the whey removed, and the solid remnants gathered together in fifteen minutes, when they are kneaded and further drained. The curd is then put into a vessel pierced with holes, and again pressed with the hands, and indeed with the body, the maker frequently getting on to the top of the mould and pressing with his knees. The mass is then reversed, and left under heavy pressure for twelve hours, being kept warm the while. Each lot of curd manipulated in this manner is called a tome—a full-size cheese requiring from three to four tomes in its manufacture.

When the real cheese-mould is about to be filled, the masses of now solid curd which we have called tomes are broken up with the fingers into small pieces, the whole salted, and finally put into the moulds in cloths, and sent to the press. Here the cheese obtains its final form, and when sufficiently solid to be removed from the mould, it is taken to the cave to ripen.

The Cantal is ripened in about two months, and when made of full rich milk is of very fine quality.

Camembert.

This is the most popular of the small cheeses of the Continent which are sent to this country. It is made upon one principle, under various forms, in the department of Calvados and in the neighbouring districts of Normandy.

In a general way the evening's milk is skimmed and added to that of the morning, and heated to from 80° to 85°, sometimes higher. There are makers, however, who make three batches daily from three several milkings, thus preventing the necessity for heating the milk.

The curd is brought by the use of rennet in from one and a half to four hours, according to the custom on the farm. While still warm it is ladled into cylindrical moulds, placed upon mats made of rush or reed, upon benches of cement or galvanised metal. Each mould is nearly filled with each batch of curd, and by the time the next curd is ready, the first will have sunk in the mould by reason of drainage, when it is again filled.

When the second curd is sufficiently low the mould is skilfully reversed, and kept upon the cheese until it is firm enough to handle; it is then salted upon one side, and left until the following day to be salted upon the other.

After salting it rests upon shelves for a few days, when it is carried to the *séchoir*, or drying-room, an apartment through which currents of air are induced to travel in all directions. Here a white mould appears; and when the pile is at its best the cheeses are conveyed to the cellar, which is usually dark, damp, and free from draught.

It is turned daily until covered with a green mould. During the growth of this fungus the flesh of the cheese will have gradually changed its condition, and in from five to six weeks it will be fit for market.

Brie.

This cheese, which is the most popular in France, is chiefly made in the department of Marne, not far from Paris, and sent to the Paris markets, where it obtains high prices. It varies from an inch to an inch and a half in thickness, and from 9 to 12 inches in diameter. Its character very much resembles that of Camembert, although it is differently made.

The new milk set at 83° is brought to a curd in from three to four hours, although details differ upon various farms. The mould is made in two parts, the top portion fitting into the bottom. This is placed upon a mat and a beech board, and the curd is laid within it in large, thin, unbroken slices until it is full. It remains to drain until the top portion of the mould can be removed; the cheese is then reversed by the aid of a clean mat and board, and in time becomes firm, when the mould is removed altogether.

It is then salted, as in the case of the Camembert, and finally taken, first to the drying-room, and subsequently to the cellar, an apartment which, as we found

in the Brie district, was not only extremely dirty, but positively reeked with fungoid growth upon the walls and shelves.

The cheese is speedily covered with white mould, with specks of blue here and there; it then goes to the cellar, and is soon covered with blue mould, upon which patches of a vermilion mould commence to grow. This blue mould is known as *Penicillium glaucum*, the red as *Oidium aurantiacum*, without which it is believed by French experts that the highest type of Brie cannot be obtained.

There is no more delicious cheese than the Brie, not even excepting the Camembert.

The Neufchatel.

This cheese, sometimes called the Bondon, is largely made in the department of Seine Inférieure. It is a small loaf-shaped cheese, about 3 inches high, and 1½ to 2 inches in diameter, and is properly made from new milk, although the majority of makers, many of whom we have visited, in this department use milk which has been partially skimmed. For such cheeses the makers obtain only a penny apiece in the Paris markets.

The majority of the makers are farmers of the smallest class, who have not sufficient milk to make large cheeses.

The milk is set directly it comes from the cow, and sufficient rennet is added to bring the curd in twenty-four hours. It is then ladled into a cloth, stretched by the four corners over a draining-tub, and left to drain for twelve hours; the partially solid curd is then removed to a press, in which it remains for some hours, until in the judgment of the maker it is fit for moulding. At this moment it is worked up with the hand, and each cheese is moulded separately in a small brass cylinder, and placed upon a straw-covered shelf to dry. Here it becomes covered with white mould, which subsequently changes to blue, the apartment being maintained at 60°, or a little less.

The cheeses are turned daily; and when a second lot of white fungus has covered the blue it is ready for the market, and will keep a long time.

This cheese is salted after it has been dried upon the shelves for a day.

The Bondon is imitated in London by East End purchasers of sour or stale milk; but it is sold to the public in a white or new state.

ASSOCIATED BUTTER AND CHEESE MAKING.

An important development of the dairy industry is the organising of establishments in which the milk produce of the cows on several different farms can be collected together for united manipulation. These establishments are of different kinds, with different yet similar aims and objects.

Creameries.—There is the "creamery," in which, as a rule, only the cream is received from the farmer. In some cases the farmer is paid for his cream by its weight or measure. In others, each farmer's cream is churned separately, and the payment made according to the produce in butter. The former is the more convenient to the creamery, the latter usually the more satisfactory to the farmer whose cream is of choice quality. A third plan, which has certain points to commend it, is for the farmer to bring the whole milk to the creamery twice a-day—just after it is milked and run through a refrigerator to cool it and prevent it spoiling on the journey—get it at once separated by the centrifugal separator, and take back with him the fresh skim-milk, which he can usually turn to better account on his farm than could be done by the creamery.

In the creamery the cream is made into butter in large quantities at a time, thus securing a product of uniform character and appearance, which is so important in the sale of butter. In some cases creameries also do a considerable trade in selling fresh cream for table use in towns.

Butter-blending House.—This is a sort of modified butter factory, in which butter is collected in small quantities from farmers, graded according to quality, and submitted to a certain amount of re-making. The object here is to rectify the home defects in the "working" of the butter, to grade, blend, and remake it, so that it may be presented in the market in large quantities of uniform character and attractive appearance.

This system has been highly successful in France, especially in Normandy, and is being carried out at various centres in this country with results which seem to be fairly satisfactory.

Dairy Factory.—Then there is the dairy factory, which, known perhaps by different names, embraces all the branches of dairying (excepting, most likely, the keeping of cows)—buying in new milk from many farmers, selling some of it as fresh whole-milk, making cheese of various kinds, separating the cream from the milk by the centrifugal separator, making butter, selling fresh cream, selling the skim-milk back to the farmers or through towns and villages, and perhaps feeding part of it to cows, calves, and pigs.

These latter are generally establishments of considerable size, and, like the creameries and butter-blending houses, are conducted in some cases as distinct businesses, and in others in co-operation with the farmers who produce and supply the raw material.

Origin and Development of Dairy Factories.

The origin and development of this peculiar outcome of dairying in this country are explained in the following notes by Mr Gilbert Murray, Elvaston Castle, Derby:—

Since 1869 the dairy management of this country has undergone a complete revolution. In that year the landowners and farmers of Derbyshire originated a movement for the improvement of cheese-making. American cheese were then taking the lead in our markets (to the great injury of the home maker) and were realising higher prices than the average prices of our home dairies. The great advantage of the foreign article was the uniform quality which it derived by being made in a factory, while in no two dairies in this country was the produce alike in quality—there was scarcely one indeed in which the quality did not vary from day to day.

After much deliberation it was at last determined to introduce some skilful American makers, in order to give the factory system a fair trial on its merits.

Two factories were started; one in the town of Derby, and the other at Longford, a purely rural district. At Derby a warehouse was improvised and fitted with the necessary machinery and plant. At Longford a new building was erected.

During the first two years, or what was then the experimental period, a fixed price was guaranteed to the suppliers of milk. After this the farmers undertook the management themselves, conducting the factories entirely on co-operative principles, and this system has since continued at the Longford Factory.

The object of the organisers of the new departure was to bring up the whole make of a district to a uniform point of excellence. This they attained, and continue to do, though meeting with considerable opposition from persons interested in the trade.

For several years the factory system made slow progress, but subsequently factories were planted in different counties. The reports and discussions to which the new departure gave rise and the authentic data as to the value of milk, were the means of enlisting public interest in dairy matters.

The cost of erecting and fitting up a cheese factory will run on an average to from 30s. to £2 per cow. The economy in working is very considerable.

Large dairy factories are now being established in different parts of the country on entirely new lines. These are manufactories on a large scale, skilfully carried out on strictly commercial principles. The output embraces every product of the dairy, from the raw material to the manufactured articles of all kinds. Some are carried on as limited liability companies, in which the farmers are shareholders.

The milk is delivered to the factory twice a-day from all distances up to four miles. As soon as the milk is drawn from the cow, it is passed over a refrigerator, figs. 420, 421, and the temperature reduced to about 60° Fahr.: in hot weather this prevents the milk from souring in transit. On arrival at the factory it is weighed and credited to the producer in the delivery book—the imperial gallon being reckoned at ten pounds.

The payments are monthly, with one month's money kept in hand to meet any case of emergency. Advances are

made to suppliers on payment of a discount at the rate of 5 per cent.

The great difficulty in the making of butter on an extensive scale is that of disposing of the bye-products — the separated milk and buttermilk. On these chiefly depend the financial success of the undertaking.

Much to their own disadvantage the farmers are chary of having anything to do with these establishments.

A butter dairy can only be successfully carried on near to a first-class station on a main line of railway.

There is much need for better organisation and more extended use of separated milk, and this must take place before dairy farming can be developed to its fullest extent in the British Isles.

Utility of the Factory System.

There is considerable difference of opinion as to the advisability of encouraging and extending the system of associated dairying. It is very properly contended that it is in itself an undesirable thing that the dairy farmer should employ others to perform work which should be done by himself and his family, or at any rate on his farm under his own eye. On the other hand, where the farms are small, or where few cows are kept, the small quantities of milk and cream may be turned to better account by being collected and manipulated in large quantities in associated dairies, than if each farmer were to prepare and market his dairy produce independently.

The factory system is assuredly very useful in its own way, and it has already done good service in this country. Yet it is by the extension and improvement of home-dairying that the lasting interests of the general body of farmers will be most effectually promoted.

END OF THE SECOND VOLUME.

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